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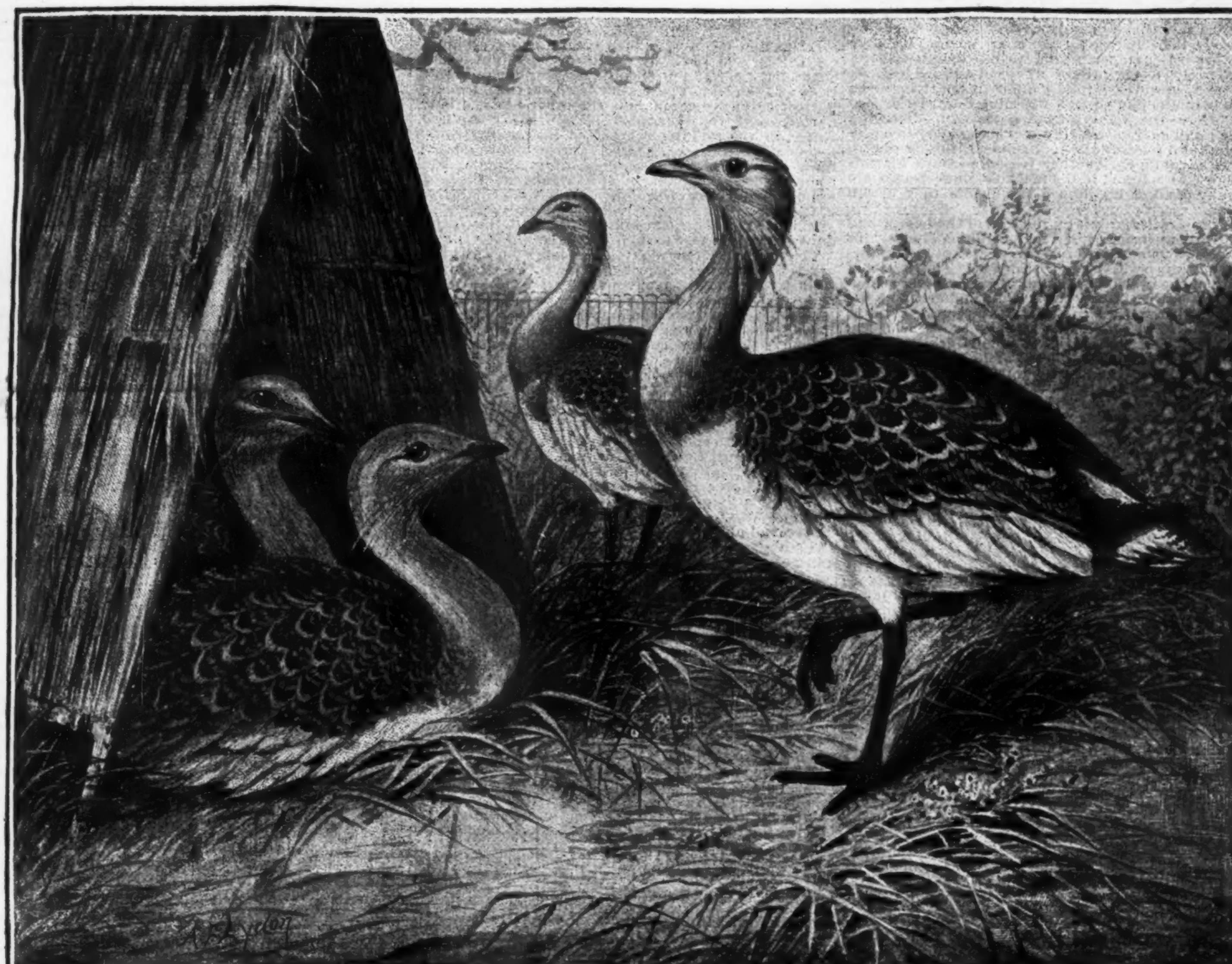
BUSTARDS AT THE ZOOLOGICAL GARDENS.

The Zoological Society of London has recently added to its collection in the Regent's Park several fine specimens of the largest species of bustard, which in South Africa is of grand size, but rarely seen except in places remote from human habitations. The Otis Kori, found on the banks of the Gariep or Orange River, is four feet high, or even bigger, and has long wings, but seldom cares to fly, running with great swiftness, and using its wings to assist its course in running; it will, however, occasionally rise and skim along just above the ground. Its body is very bulky and heavy, abounding in fat, and the flesh of this bird is much esteemed as meat, its flavor being like that of a turkey. The natives of Africa are accustomed to catch the bustard in snares. They say that a single bustard is usually to be seen accompanying a herd of gazelles.—*Illustrated London News.*



GREAT BUSTARDS RECENTLY ADDED TO THE ZOOLOGICAL SOCIETY'S GARDENS, LONDON.

THE SHAPES OF LEAVES AND COTYLEDONS.*

By Sir John Lubbock.

Attempts to explain the forms, colors, and other characteristics of animals and plants, though not new, were until recent years far from successful. Our Teutonic forefathers had a pretty story which explained certain characteristics of several common plants.

Balder, the God of Mirth and Merriment, was, characteristically enough, regarded as deficient in the possession of immortality. The other divinities, fearing to lose him, petitioned Thor to make him immortal, and the prayer was granted on condition that every animal and plant would swear not to injure him. To secure this object, Nanna, Balder's wife, descended upon the earth. Loki, the God of Envy, attended her disguised as a crow (crows at that time were white), and settled on a little blue flower, hoping to cover it up so that she might overlook it. The flower, however, cried out "Forget-me-not, forget-me-not" (and has ever since been known under that name). Loki then flew up into an oak and sat on a mistletoe. Here he was more successful. Nanna carried off the oath of the oak, but overlooked the mistletoe. She thought, however, and the divinities thought, that she had successfully accomplished her mission, and that Balder had received the gift of immortality.

One day, thinking Balder proof, they amused themselves by shooting at him, posting him against a holly. Loki tipped an arrow with a piece of mistletoe, against which Balder was not proof. This unfortunately pierced him to the heart, and he fell dead. Some drops of his blood dropped on the holly, which accounts for the redness of the berries; the mistletoe was so grieved that she has ever since borne fruit like tears, and the crow, whose form Loki had taken, and which till then had been white, was turned black.

This pretty myth accounts for several things, but is open to fatal objections. You will judge whether I am more fortunate. In the first place, I need hardly observe that the forms of leaves are almost infinitely varied. To quote Ruskin's vivid words, they "take all kinds of strange shapes, as if to invite us to examine them. Star-shaped, heart-shaped, spear-shaped, arrow-shaped, fretted, fringed, cleft, furrowed, serrated, sinuated, in whorls, in tufts, in spires, in wreaths, endlessly expressive, deceptive, fantastic, never the same from footstalk to blossom, they seem perpetually to tempt our watchfulness, and take delight in outstripping our wonder."

Now, why is this marvelous variety, this inexhaustible treasury of beautiful forms? Does it result from some innate tendency of each species? Is it intentionally designed to delight the eye of man? Or has the form and size and texture some reference to the structure and organization, the habits and requirements, of the whole plant?

The leaf, although so thin, is no mere membrane, but is built up of many layers of cells, and the interior communicates with the external air by millions of little mouths, called stomata, which are generally situated on the under side of the leaf. The structure of leaves varies as much as their forms.

It is, of course, principally in hot and dry countries that leaves require protection from too much evaporation.

The surface is in some cases protected by a covering of varnish, in others by saline or calcareous excretions. In others, again, the same object is attained by increased viscidity of the sap; in some, the leaves assume a vertical position, thus presenting a smaller surface to the rays of the sun. In other cases the leaves become fleshy. Woolly hairs are also a common and effective mode of protection.

The plants of deserts are very frequently covered with a thick felt of hair. Some species, again, which are smooth in the north tend to become woolly in the south. Species of the cool spring again tend to be glabrous. The uses of hairs to plants are indeed very various. They serve, as just mentioned, to check too rapid evaporation. They form a protection for the stomata or breathing holes, and consequently, as these are mainly on the under side of leaves, we find that when one side of the leaf is covered with white felted hairs, as the white poplar, this is always the under side.

In other cases the use of hair is to throw off water. In some Alpine and marsh plants this is important. If the breathing holes become clogged with moisture—with fog, for instance, or dew—they would be unable to fulfill their functions. The covering of hair, however, throws off the moisture, and thus keeps them dry. Thus these hairs form a protection both against too much drought and too much moisture.

* Lecture delivered at the Royal Institution on April 25, 1890, by Sir John Lubbock, Bart., M.P., D.C.L., F.R.S., etc.—*Nature.*

Another function of hairs which cannot be omitted is to serve as shades against too brilliant light and too much heat. Again, hairs serve as a protection against insects, and even against larger animals. The stinging hairs of the common nettle are a familiar example, and coarse woolly hairs are often distasteful to herbivorous quadrupeds.

Deciduous leaves especially characterize the comparatively cool and moist atmosphere of temperate regions. For different reasons evergreen leaves become more numerous in the Alps and in the tropics.

In the Alps it is necessary for plants to make the most of the short summer. Hence, perennial and evergreen species are more numerous in proportion than with us. Everybody must have noticed how our trees are broken if we have snow early in the season and when they are still in leaf.

The comparatively tough and leathery leaves, such as those of the evergreen oak and olive, are protected against animals by their texture, and often, as in the holly, by spines; they are better able to resist the heat and dryness of the south than the comparatively tender leaves of our deciduous trees, which would part too rapidly with their moisture. It is perhaps an advantage to evergreen leaves to be glossy, because it enables them better to throw off snow. Moreover, their stomata are often placed in pits, and protected with hair, which prevents too rapid evaporation. The texture and structure of leaves is indeed a wide and very interesting subject, but to-night I must confine myself to the shape.

CORDATE AND LOBED LEAVES.

Among broad leaves we may observe two distinct types, according as they are oval or palmate. Monocotyledonous plants, such as grasses, sedges, lilies, hyacinths, very generally have upright and narrow leaves. When they are wider, as, for instance, in the black bryony, this is mainly at the base, where, consequently, the veins are further apart, coming together again toward the apex. This we are tempted therefore to regard as the primitive type of a broad leaf.

There is, however, a totally different one, where the leaf is palmate, like a hand, widening toward the free end. Here the veins pursue a straight, diverging course ; and as they not only serve to strengthen the leaf, but also to carry the nourishment, this is doubtless an advantage. Another reason perhaps for this arrangement is found in the fact that these leaves are generally folded up, like a fan, while they are in the bud.

I have elsewhere dwelt on the case of the beech, and perhaps I may briefly refer to it again. The weight of leaves which a branch can carry will of course depend on its position and strength. The mode of growth of the beech and the hornbeam are very similar, but the twigs of the latter are slenderer, and the leaves smaller. If we cut off a beech branch below the sixth leaf, we shall find that the superficial leaf area which it carries is about 18 square inches. But in our climate most leaves are glad of as much sunshine as they can secure, and are arranged with reference to it. The width of the beech leaves, about 1¾ inch, is regulated by the average distance between the buds. If the leaves were wider, they would overlay. If they were narrower, there would be a waste of space. The area on the one hand, and the width on the other, being thus determined, the length is fixed, because to secure an area of 18 inches, the width being about 1¾ inch, the length must be about two inches. This, then, explains the form of the beech leaf.

Let us apply these considerations in other cases. I will take, for instance, the Spanish chestnut and the black poplar. In the Spanish chestnut the stem is much stronger then that of the beech. Consequently it can carry a greater leaf surface. But the distance between the buds being about the same, the leaves cannot be much wider ; hence they are much longer in proportion, and this gives them their peculiar sword-blade-like shape.

Now, if we look at the end of a branch of black poplar and compare it with one of white poplar, we are struck with two things : in the first place the branch cannot be laid out on a sheet of paper so that the leaves shall not overlap ; the leaves are too numerous and large. Secondly, in the white poplar the upper and under surfaces of the leaf are very different, the lower one being covered with a thick felt of hair, which gives it its white color ; in the black poplar, on the other hand, the two surfaces are nearly similar.

These two characteristics are correlated, for while in the white poplar the leaves are horizontal, in the black poplar, on the contrary, they hang vertically. Hence the two surfaces are under very similar conditions, and consequently present a similar structure ; while for the same reason they hang free from one another.

Let us again look for a moment at the great group of conifers. Why, for instance, do some have long leaves and some short ones ? This, I believe, depends on the strength of the twigs and the number of years which the leaves last ; long leaves dropping after one, two, or three years, while species with shorter ones retained them many years—the spruce fir, for instance, 8 or 10, *Abies Pinsapo* even as many as 18.

[Here Sir John dwelt on and explained the forms of several familiar leaves.]

SEEDLINGS.

I now come to the second part of my lecture—the forms of cotyledons. Any one who has ever looked at a seedling plant must have been struck by the fact that the first leaves differ entirely from those which follow, not merely from the final form, but even from those which immediately follow. These first leaves are called cotyledons. The forms of many cotyledons have been carefully described, but no reason had been given for the forms assumed, nor any explanation offered why they should differ so much from the subsequent leaves. Klebs, indeed, in his interesting memoir on "Germination," characterizes it as quite an enigma.

Mustard and cress were the delight and wonder of our childhood, but it never then occurred to me at least to ask why they were formed as they are. So they grew, and beyond that it did not occur to me, nor I think to most, that it was possible to inquire. I have however, I think, suggested plausible reasons in many cases, some of which I will now submit for your consideration. Cotyledons differ greatly in form.

Some are narrow, in illustration of which I may mention the fennel and ferula, in the stalk or ferule of which Prometheus is fabled to have brought down fire from heaven.

Some are broad, as in the beech and mustard. Moreover, some species have narrow cotyledons and broad leaves, while others have broad cotyledons and narrow leaves.

Some are emarginate, as in the mustard ; lobed, as in the lime ; bifid, as in Eschscholtzia ; trifid, as in the cress ; or with four long lobes, as in Pterocarya.

Some are unequal, as in the mustard, or unsymmetrical, as in the geranium.

Some are sessile, and some are stalked, some are large, some small.

Generally they are green, leaf-like, and aerial, but sometimes they are thick and fleshy, as in the oak, nut, walnut, peas, beans, and many others, in which they never quit the seed at all.

Let us see, then, whether we can throw any light on these differences, and why they should be so unlike the true leaves.

If we cut open a seed, we find within it the future plant ; sometimes, as in the larkspur, a very small oval body ; sometimes, as in the ash, or the castor oil, a lovely little miniature plant, with a short stout root and two well formed leaves, inclosing between them the rudiment of the future stem ; the whole lying embedded in food material or perisperm ; while sometimes the embryo occupies the whole interior of the seed, the food material being stored up, not round, but in the seed leaves or cotyledons themselves. Peas and beans, almonds, nuts, and walnuts are familiar cases. In split peas, for instance—Who split the peas? If you look at them, you will see that it is too regularly and beautifully done for human hands. In fact, the two halves are the two fleshy cotyledons ; strictly speaking, they are not split, for they never were united.

NARROW COTYLEDONS.

Let us now begin with such species as have narrow cotyledons, and see if we can throw any light on this characteristic. The problem is simple enough in such cases as the plane, where they have, on the one hand, narrow cotyledons, and, on the other hand, a long, narrow seed fully occupied by a straight embryo. Again, in the ash, the cotyledons lie parallel to the longer axis of the seed, which is narrow and elongated. Such cases are, however, comparatively few ; and there are a large number of species in which the seeds are broad and even orbicular, while yet the cotyledons are narrow.

In these it will generally be found that the cotyledons lie transversely to the seed.

The sycamore has also narrow cotyledons, but the arrangement is very different. The fruit is winged, the seed is somewhat obovoid and aperispermic—that is to say, the embryo, instead of lying embedded in food material, occupies the whole cavity of the seed. Now, if we wished to pack a leaf into a cavity of this form, it would be found convenient to choose one of a long strap-like shape, and roll it up into a sort of ball. This is, I believe, the reason why this form of cotyledon is most suitable in the case of the sycamore.

BROAD COTYLEDONS.

I now pass to species with broad cotyledons. In the castor oil plant, Euonymus, or the apple, for instance, the young plant lies the broad way of the seed, and the cotyledons conform to it. In the genus Coreopsis, *Coreopsis auriculata* has broad cotyledons, and *Coreopsis filifolia* has narrow ones—the first having broad, the second narrow seeds.

In a great many species the cotyledons are emarginate—that is to say, they are more or less deeply notched at the end. This is due to a variety of causes. One of the simplest cases is that of the oak, where the two fleshy cotyledons fill the seed ; and as the walls of the seed are somewhat thickened at the end, and project slightly into the hollow of the seed, this causes a corresponding depression in the cotyledons.

In such cases as the mustard, cabbage, and radish, the emargination is due to a very different cause. The seed is oblong, thick, and slightly narrower at one end than the other. There is no perisperm, so that embryo occupies the whole seed, and as this is somewhat deep, the cotyledons, in order to occupy the whole space, are folded and arranged one over the other like two sheets of note paper, the radicle being folded along the edge. To this folding the emargination is due. If a piece of paper be taken, folded on itself, cut in the form of the seed, and then unfolded, the reason for the form of the cotyledon becomes clear at once.

But it may be said that in the wall flower the seed has a similar outline, and yet the cotyledons are not emarginate. The reason of this is that in the wall flower, Cheiranthus, the seed is more compressed than in the mustard and radish, and consequently the cotyledons are not folded ; so that the whole, not the half, of each cotyledon corresponds to the form of the seed.

LOBED COTYLEDONS.

The great majority of cotyledons are entire, but some are more or less lobed. For instance, those of the mallow are broadly ovate, minutely emarginate, cordate at the base, and three-lobed or angled toward the apex, with three veins, each running into one of the lobes.

The embryo is green, curved, and occupies a great part of the seed. The cotyledons are applied face to face ; then, as growth continues, the tip becomes curved and depressed into a median longitudinal furrow, the fold of the one lying in that of the other.

[Sir John then showed clearly by diagrams and paper how the emargination arises, but it cannot be made clear without illustrations.]

The cotyledons of the line are very peculiar. They are deeply five-lobed, the central lobe being the longest ; so that they are roughly shaped like a hand. The seed is an oblate spheroid, resembling an orange in form, and the embryo is embedded in semi-transparent albumen.

The embryo is at first straight ; the radicle is stout and obtuse ; the cotyledons ovate-obtuse, plano-convex, fleshy, pale green, and applied face to face. They grow, however, considerably, and when they meet the wall of the seed, they bend back on themselves, and then curve round, following the general outline of the seed. If any one will take a common tea cup and try to place in it a sheet of paper, the paper will, of course, be thrown into ridges. If these ridges be removed and so much left as will lie smoothly inside the cup, it will be found that the paper has been cut into lobes more or less resembling those of the cotyledons of Tilia. Or if, conversely, a piece of paper be cut into lobes resembling those of the cotyledons, it will be found that the paper will fit the concavity of the cup. The case is almost like that of our own hand, which can be opened and closed conveniently, owing to the division of the five fingers.

UNEQUAL COTYLEDONS.

In most cases the two cotyledons are equal, but there are several cases in which one of them is larger than the other. They had not escaped the attention of Darwin, who attributed the difference to the fact "of a store of nutriment being laid up in some other part, as in the hypocotyl, or one of the cotyledons." I confess that I do not quite see how this affords any explanation of the fact. The suggestion I have thrown out is that the difference is due to the relative position of two cotyledons in the seed, which in some cases favors one of them at the expense of the other. Thus in the mustard they are unequal, and as we have already seen, they are folded up, one inside the other. The outer one, therefore, has more space, and becomes larger. In many other Crucifers, though the cotyledons are not folded, they are what is called "incumbent"—that is to say, they are folded on the radicle, and the outer one has therefore more room than the other.

UNSYMMETRICAL COTYLEDONS.

In other cases, as in the geraniums, laburnum, lupines, etc., there is inequality, not between the two cotyledons, but between the two halves of each cotyledon. In the geraniums this is due to the manner in which the cotyledons are folded. In cabbage and mustard we have seen that one cotyledon is folded inside the other ; in the geranium they are convolute, one-half of each being folded inside one-half of the other, the two inner halves being the smaller, the two outer the larger ones.

In the laburnum, where the arrangement is very similar, the inequality in the two sides of the cotyledon is due to the inequality between the two sides of the seed.

SUBTERRANEAN COTYLEDONS.

I have already observed that in some cases the cotyledons occupy the whole of the seed, which, in more or less spherical seeds, is effected either by a process of folding and packing, or by the cotyledons becoming themselves more or less thickened, as in peas and beans, nuts and chestnuts. This is the reason why such seeds fall more or less readily into two halves, the radicle or plumule being so small in comparison as generally to escape notice, though, if a horse chestnut is peeled, the radicle appears as a sort of tail.

In some beans the cotyledons sometimes emerge from the seed, sometimes remain underground. In others, as also in the oak and horse chestnut, they never leave the seed, or come above ground ; they have lost the function of leaves and become mere receptacles of nourishment.

Did it ever occur to you to think, when you have been eating walnuts, why their structure is so complex, and why the edible part is thrown into those complicated lobes and folds ? The history is very interesting.

In the walnut, the cotyledons now never leave the seed, but in an allied genus, Pterocarya, they come above ground as usual, and are very peculiar in form, being deeply four-lobed. The reason of this is very curious. The fruit is originally much larger than the seed, but, as it approaches maturity, the hard woody tissue disintegrates at four places, leaving thus four hollow spaces. Into these spaces the seed sends four projections, and into these four projections each cotyledon sends a lobe. Hence the four lobes.

Now in the walnut a very similar process takes place, only the hollow spaces are much larger, so that, instead of a solid wall, with hollow spaces occupied by the seed, it gives the impression as if the seed was thrown into folds occupied by the wall of the fruit. To occupy these spaces fully, the cotyledons themselves were thrown into folds as we now see them. The fruit of Pterocarya is much smaller than that of the horse chestnut, which doubtless was itself formerly not so large as it now is. As it increased, the cotyledons became fleshier and fleshier, and found it more and more difficult to make their exit from the seed, until at last they have given up any attempt to do so. Hence these curious folds, with which we are so familiar, are the efforts made by the originally leafy cotyledons to occupy the interior of the nut. If you separate them, you will easily find the little rootlet, and the plumule with from five to seven pairs of minute leaves.

But perhaps you will ask me why I have assumed that in these cases the cotyledons have conformed to the seeds ? May it not be that the seed is determined, on the contrary, with reference to the cotyledons? The size, form, etc., of the seeds, however, evidently have relation to the habits, conditions, etc., of the parent plant.

Let me, in illustration, take one case. The cotyledons of the sycamore are long, narrow, and strap-like ; those of the beech are short, very broad, and fan-like. Both species are aperispermic, the embryo occupying the whole interior of the seed.

Now, in the sycamore, the seed is more or less an oblate spheroid, and the long ribbon-like cotyledons, being rolled up into a ball, fit it closely, the inner cotyledon being often somewhat shorter than the other. On the other hand, the nuts of the beech are more or less triangular : an arrangement like that of the sycamore would therefore be utterly unsuitable, as it would necessarily leave great gaps. The cotyledons, however, are folded up like a fan, but with more complication, and in such a manner that they fit beautifully into the triangular nut.

Can we, however, carry the argument one stage further ? Why should the seed of the sycamore be globular, and that of the beech triangular ? Is it clear that the cotyledons are constituted so as to suit the seed ? May it not be that it is the seed which is adapted to the cotyledons ? In answer to this we must examine the fruit, and we shall find that in both cases the cavity of the fruit is approximately spherical. That of the sycamore, however, is comparatively small, say

½ inch in diameter, and contains one seed, which exactly conforms to the cavity in which it lies. In the beech, on the contrary, the fruit is at least twice the size, and contains from two to four fruits, which consequently, in order to occupy the space, are compelled (to give a familiar illustration, like the segments of an orange) to take a more or less triangular form.

Thus, then, in these cases, starting with the form of the fruit, we see that it governs that of the seed, and that of the seed, again, determines that of the cotyledons. But though the cotyledons often follow the form of the seed, this is not invariably the case: other factors must also be taken into consideration; but when this is done, we can, I venture to think, throw much light on the varied forms which seedlings assume.

I have thus attempted to indicate some of the principles on which, as it seems to me, the shapes of leaves and seedlings depend, and to apply them in certain cases, but the study is only in its infancy: the number and variety of leaves is almost infinite, and the whole question offers, I venture to think, a very interesting field for observation and research—one, indeed, of the most fascinating in the whole of natural history.

HONEYSUCKLES.

THE common honeysuckle of the hedgerow and wood creates many pretty pictures in English gardens. It covers the tree stump, arch, and pillar with its twining growth, smothers the humble doorway of the cottage, or scrambles in at the latticed window, filling the air with the sweetest of scents. There are other honeysuckles than the common one, and other ways of growing them than nailed to walls, or stiffly trained with shreds and ties. Few more beautiful pictures could be made than by planting one or other of the honeysuckles at the foot of an arch, and permitting the plant to grow unmolested over the wood or wirework, which it quickly hides. Just train out the growth to prevent it becoming entangled, but allow the shoots to spread about in their own charming and graceful way. A pillar of honeysuckles is of rich beauty and may be made by putting in strong stakes, each from eight feet to twelve feet high, but they must be strong to support the dense growth. Honeysuckles might also be planted on dead tree stems, as we frequently see roses, which clamber over them, making a cloud of color in the garden in the summer. It is in such happy ways that we obtain the beauty of the Loniceras, and not when simply trained to walls. The illustration that accompanies this note shows the delightful picture that may be made by planting honeysuckles over an arch; the luxuriant growth, dangling shoots, and profuse display of the small yellowish flowers are brought out in their fullness. There is no stiffness in growing the honeysuckle, as portrayed in the engraving. We have, besides the wild kind, the pretty Dutch and late Dutch varieties, flexuosa, characterized by purplish stems and hairy leaves, and L. japonica, also known as halleana, which is of elegant growth and very free blooming, the white flowers appearing in July and August. Then we have L. flava and the vigorous growing trumpet honeysuckles, L. sempervirens and the variety minor. These are two beautiful kinds for a cold house, and the freest to bloom is minor, which with the type will succeed well out of doors in a light soil and warm situation. They are not so hardy as caprifolium and the other forms.

A class of honeysuckles is that known as the bush, of which standishi and fragrantissima are well known varieties. They are not climbers strictly, but we frequently see them planted against walls, as in the royal gardens, Kew, where they flower in midwinter, scenting the air around with a sweet fragrance. L. flexuosa aureo reticulata is conspicuous for its richly colored foliage, netted with gold, but we do not care for such plants in the garden while there are so many finer types. A rare kind, but very elegant in growth, is L. acuminata, which comes from the Himalayas, and bears purple flowers in July.—*The Garden.*

AN ARCH COVERED WITH HONEYSUCKLE.

[NATURE.]

ASTRONOMY.

OBJECTS FOR THE SPECTROSCOPE.

SIDEREAL time at Greenwich at 10 P. M. on May 22 = 14 h. 1 m. 54 s.

Name.	Mag.	Color.	R. A. 1890.	Decl. 1890.
			h. m. s.	° ′
(1) G.C. 3770....	.....	White.	13 59 17	+52 54
(2) 69 Virginis..	5·5	Yellowish-white.	13 21 35	−15 24
(3) B A.C. 4690..	5	Yellowish-red.	14 3 32	+44 23
(4) 20 Bootis....	5	Yellow.	14 14 36	+16 49
(5) η Bootis....	3	Yellowish-white.	13 49 30	+18 57
(6) U Cygni	var.	Very red.	20 16 11	+47 33

REMARKS.

(1) This very large nebula (101 M Bootis) has not yet been spectroscopically examined. According to the Parsonstown observations, it is at least 14′ across, and exhibits a spiral structure with arms and knots. It is everywhere faint except in the middle. In the "General Catalogue" it is described as "Pretty bright, irregularly round, at first gradually, then very suddenly much brighter in the middle to a small bright nucleus." The spectrum of such a diffused mass is likely to possess great interest, and the nebula is so large that it will probably not be difficult to differentiate the spectra of different regions.

(2) In his catalogue of stellar spectra, published in 1887, Konkoly records an observation of this star, in which bright lines were strongly suspected. Notwithstanding the recent additions to this group by Prof. Pickering and Mr. Espin, the number is still very small, and it is important that suspected cases should be fully investigated. The lines suspected by Konkoly in 69 Virginis were C, D_3, and F—the three commonly observed in *b* Lyræ and *γ* Cassiopeiæ. It is quite possible that the appearance of the lines is periodic, and observations should, therefore, be continued for some time. If the lines are of any considerable brightness, the observations ought not to be difficult, as the bright lines in the 8th magnitude stars in Cygnus are easily seen and measured with 10 in. aperture. Any irregularities in the continuous spectrum, especially in the green and blue, should be noted; and, if possible, comparisons should be made with the carbon flutings. Prof. Lockyer has pointed out that a line near λ 447 is associated with D_3 in the Orion nebula, and also in the solar chromosphere, and it is important to observe whether this also applies to the bright-line stars. He has demonstrated by photographs that the line in the nebula (447) is coincident with one of the bright lines photographed by Prof. Pickering in P Cygni.

(3) Duner describes the spectrum of this star as a magnificent one of group II., particularly in the red end. The bands 1–9 are all strongly marked. The star is thus probably a little more advanced in condensation than the mean species of the group, and it will be interesting to know what line absorptions appear at this stage, and also what is the extent of carbon radiation.

(4 and 5) These are given in Vogel's catalogue as stars of the solar type and of group IV. respectively. The usual observations are required in each case.

(6) This is one of the very few variables with spectra of group VI. So far we have no records of any changes in spectra which may accompany the variations in magnitude, and the cause of the variability is, consequently, very imperfectly understood. Duner says that the spectrum consists of three zones rather feebly developed, band 6 (near λ 564) being weak, but he does not state the magnitude of the star at the time of his observation. The next maximum will occur about May 28. The star ranges from about magnitude 7·5 to < 11 in a period of 461 days. Changes of color should also be noted.

A. FOWLER.

Spica.—At the Berlin Academy of Sciences on April 24, Prof. Vogel announced that Spica consists of two close stars revolving round their common center of gravity. The star's spectrum is that of class IV., and twice in April, 1889, the F line appeared to be shifted toward the violet end of the spectrum as compared with the H *b* line given by a vacuum tube, while once in the following month the shift appeared to be toward the red end. These observations and others made this year of the star's motion in line of sight are given in the following table, approach to the sun being indicated by (—) and recession from the sun by (+), both being expressed in German miles per second:

Potsdam Mean Time.	Observed Motion.	Relative to the Sun.	✱—
h. m.			
1889, April 21, 9 15	− 11·6	− 0·7	− 12·3
" 29, 11 10	− 12 0	− 1·2	− 13·2
May 1, 10 58	+ 7·5	− 1·3	+ 6·2
1890, April 4, 11 30	− 3·4	+ 0·5	− 2·9
" 9, 10 30	− 14·2	+ 0·2	− 14·0
" 10, 11 30	− 0·3	+ 0·1	− 0·2
" 11, 10 50	+ 7·6	0·0	+ 7·6
" 13, 10 50	− 14·7	− 0·1	− 14·8
" 15, 10 00	+ 11·3	− 0·3	+ 11·0

The observations have been reduced to the epoch 1890, April 2, 10 h., Potsdam mean time, and the period of revolution of the system determined as 4 days 0·3 hour. The greatest motion in line of sight due to the orbital velocity is about 12 miles a second, and the system as a whole is moving toward the earth with a velocity of about 3 miles a second.

From this it is found that the distance between the components of the system is 660,000 miles, and their total mass = 1·2 that of the sun.

It will be remembered that Algol is a spectroscopic double of the same character as the above described.

The Meteoric Theory of Comets.—In the *Sidereal Messenger* for May, Mr. W. H. S. Monck discusses the evidence that has been brought forward in support of this theory, and in connection with the meteoritic origin of the universe. Only four comets are definitely known to be connected with meteor showers; and conversely only four meteor showers have been connected with comets; these comets are all periodic, the longest periodic being 415 years. From this fact it is argued that there is not sufficient evidence to allow the assertion that all comets are connected with meteor swarms, and that the ejection theory advocated by the late Mr. Proctor is supported. It is asserted that, since an ejection from a rapidly cooling body may be partly solid, partly liquid, and partly gaseous, the gaseous matter might form the comet and the solid (or solidified) matter form the attendant meteors; but for this origin to be true the assumption must be made that two planets exist beyond Neptune. Mr. Monck argues that because Arcturus was seen through 90,000 miles of Donati's comet, whereas Saturn's rings (except, perhaps, the inner crape ring) are not transparent, the rings must be more than one thousand times as dense as the comet at the point where it crossed between us and Arcturus, hence meteoritic collisions should be more frequent and the effect of the increased temperature should be made clearly manifest in the spectrum. The meteoritic hypothesis is not, however, objected to as a working hypothesis, but is said to be on an equality with the older nebular hypothesis; and the writer does not think the spectroscope will ever afford a crucial test between the two, for the reason that it cannot distinguish between a large solid surrounded by a gaseous envelope and a number of small bodies with interspaces filled with gas.

Mass of Shooting Stars.—Mr. C. C. Huchins, in the *American Journal of Science* for May, gives the result of an investigation undertaken with the object of finding data for determining the mass of shooting stars. Having determined the radiant energy of the standard candle, it was found that on the supposition that the rays of a meteor have the same ratio of visible to total energy as those of the candle, the mass of a meteor at a distance of fifty miles, having a magnitude equal to Vega and a velocity of twenty-five miles per second, would be 0·2936 gramme if it continued two seconds. If the meteor in burning produce, for a given expenditure of energy, more light than the candle, then a less mass would serve to produce the light given by it. A lump of the Emmett Co. (Iowa) iron meteorite was placed upon the lower carbon of an arc lamp and vaporized by the passage of the current, and it was found that for a given expenditure of energy the arc of meteoritic vapor gave ten times the light of the candle, hence the mass of a meteor giving the light of a first magnitude star moving with parabolic velocity, and lasting for two seconds, is 0·029 gramme.

Photographs of the Moon.—Admiral Mouchez, at the meeting of the Paris Academy of Sciences of May 12, presented a note on some new photographs of the moon obtained by the Brothers Henry at Paris Observatory. The instrument used was the equatorial 0·32 meter aperture, destined for the map of the heavens. The photographs are said to be far superior to those obtained in England and the United States with larger apertures, the superiority of the results being ascribed not only to the perfection of MM. Henry's objectives, but also to the method of direct enlargement adopted.

VELOCITY OF THE WIND ON THE EIFFEL TOWER AND AT THE FORTH BRIDGE.

FOR some months measurements of the velocity of the wind were made at the top of the Eiffel tower last year, and of some of these we have given the results. Since then M. Angot has published the results of numerous observations. The measurements were taken on two Richard anemometers, one on the top of the tower at an elevation of about 994 ft., the other at the office of the meteorological service, at an elevation of 69 ft. above the level of the ground. The horizontal distance between the two stations is about 1,640 ft. Up to the 1st of October 101 days' observations were made; 12 in June, 28 in July, 31 in August, and 30 in September. The daily variations in the velocity of the wind follow the same laws in each month, but it is not the same for the higher station and for the lower one. While at the latter the daily increase and diminution in the velocity follows the increase and diminution of the temperature, the opposite of this holds true upon the top of the tower.

The average of all the observations is 23·12 ft. a second at the top of the tower and 7·35 ft. at the station of the meteorological service, which shows that the velocity at the higher point is about 3·1 times as great as the other. The velocity at the 994 ft. station is much greater than usually believed. During 101 days it exceeded 23 ft. a second. During 2,516 hours of observation the velocity was more than 26·2 ft. for 39 per cent. of the time, over 32·8 ft. for 21 per cent. of the time.

In designing the Eiffel tower, such an increase in the velocity of the wind with increase in elevation was not assumed. The calculations were made upon two assumptions; the first that the pressure of the wind was 61·444 lb. per sq. ft. on all parts of the structure, the other assumption was that the pressure increased from 40·96 lb. at the base to 81·92 lb. at the top. In the second assumption the pressure is twice as great above as below, therefore the velocity above is not quite one and one-half times that below. Moreover, it is improbable that during very heavy storms the velocity above is three times that below, the pressure, therefore nine times as great. A glance at the table below shows that the difference between the velocities diminishes as they increase. For the lowest velocities below, those above are from 4·3 to 5 times as great. For the great-

MEAN VELOCITY OF THE WIND IN FEET PER SECOND AT THE EIFFEL TOWER.

Hour.	Tower.	Office.	Ratio.
5 a. m....................	24·6	4·9	5·0
4 "	25·3	5·25	4·8
2 "	26·6	5·3	5·0
3 "	26·2	5 3	4·9
6 "	23·2	5·4	4 3
1 "	27·6	5·6	4·9
0 midnight..............	27·7	6·0	4·6
7 a. m..................	21·46·1	6·1	3·5
11 p. m..................	28·7	6·3	4·5
9 "	26·6	6·5	4·1
8 "	25·3	6·6	3·8
10 "	28·2	6·8	4·2
8 a. m..................	18·4	6·85	2·7
7 p. m..................	22·9	6·9	3·3
9 a. m..................	17·9	7·8	2·3
6 p. m..................	22·0	8·0	2·7
10 a. m..................	17·5	8·7	2 0
5 p. m..................	21·9	9·0	2·4
3 "	20·7	9·2	2·2
4 "	21·1	9·25	2·3
11 a. m..................	19·5	9·7	2·0
12 noon..................	19·7	10·0	2·0
2 p. m..................	21·1	10·0	2·1
1 "	20·7	10·4	2·0

est values below, however, those above bear the ratio to those below of only 2·0 or 2·1 to 1. If the difference diminishes in this way with still greater velocities, Eiffel's assumption of 41 lb. below and 82 lb. above must be considered very well founded.

The usual formula for the pressure on a surface at right angles to the direction of the wind is

$$P = 0{\cdot}12248v^2;$$

where P is the pressure in kilos. per square meter, v is the velocity in meters a second. Or, in English units,

$$P = 0{\cdot}00206v^2;$$

where P is the pressure in pounds per square foot, v is the velocity in feet per second.

During the storm of February 9, 1889, the pressure per square foot at the Forth bridge, on a surface of 193·7 square feet, was 27·03 lb., while the pressure on a surface of only 96·85 square feet was 40·96 lb. From these and similar observations the *Centralblatt der Bauverwaltung* infers that the pressure per square foot varies inversely as the areas exposed to the action of the wind, the velocity remaining the same.

MODERN FRENCH ARTILLERY.

THE GUN FACTORY OF THE CAIL.

THE exhibit of artillery that was made at the Paris exhibition last year afforded a good illustration of what the Anciens Etablissements Cail were doing in this direction; the large number of guns they displayed in their pavilion gave, of course, no indication of the amount of work they had then in hand of this description; nor is it essential to our present purpose, which is simply to describe the different types of ordnance made by them. Some information on the subject, however, was supplied by the company in the hand book referring to their exhibit; from this we learn that it was in 1877, after a long series of experiments, that had lasted through four years, that the French war office accepted the De Bange system and introduced it into the field artillery service. The first calibers that were supplied and passed into the army were delivered in the year just mentioned, and were of 3·15 in. and 3·54 in. bore. Some years after this date a number of large types were made by Cail for the government; mountain and siege guns, some for naval and coast defense, ordnance, and rifled mortars. Naturally certain improvements and modifications were gradually introduced into the system, and within four or five years the company was in a position to fill orders from abroad as well as those they received from the government at home. Since the year 1882 the following is the list of guns furnished by them, and of the purchasing countries:

1. Mexico.—8 batteries of field guns and 8 batteries of mountain guns.
2. Servia.—45 batteries of field guns and 7 of mountain guns. It should be mentioned with regard to Nos. 1 and 2 that these orders were filled jointly by the Cail and the St. Chamond companies, as has been stated in a previous article.
3. Sweden.—2 batteries of field guns.
4. Costa Rica.—1 battery of field guns and 2 of mountain guns.
5. Denmark.—1 gun of 149 mm. (5·86 in.) and carriage fitted with hydraulic brake.
6.—Brazil.—1 naval gun of 179 mm. (7·04 in.), mounted on a carriage fitted with hydraulic brake, and one rifled mortar of 3·15 in.

Making a total of 441 guns and 489 carriages.

The following is a list of material supplied by the company to the French government, the Cail company securing the contract on account of their favorable prices. There are more than twelve firms in France which are asked for tenders, and the order is always given to the firm who quotes the lowest price.

A. For the navy:

75 guns of 65 mm. (2·56 in.)
25 guns of 140 mm. (5·51 in.)
31 carriages for quick-firing 65 mm. guns (2·56 in.)
55 ditto for guns of 140 mm. (5·51 in.)
27 carriages for guns of 160 mm. (6·29 in.)
19 carriages for guns of 190 mm. (7·47 in.)
9 carriages for guns of 240 mm. (9·45 in.)
7 carriages for guns of 270 mm. (10·63 in.)
175 torpedo tubes completely fitted.

B. For the war department:

130 carriages for guns of 155 mm. (6·10 in.)
1 non-recoil carriage for a mortar of 155 mm. (6·10 in.)
1 non-recoil carriage for mortar of 220 mm. (8·66 in.)

Besides a large quantity of ammunition.

Prior to the year 1882 the Cail company had manufactured for the state a large number of carriages both for the marine and the army. For the former they had made:

50 carriages for guns 100 mm. (3·94 in.)
165 carriages for guns of 140 mm. (5·51 in.)
69 carriages for guns of 190 mm. (7·47 in.)

And for the war department:

103 carriages for small casemate guns.
413 carriages for similar guns of larger caliber.
300 carriages for guns of 90 mm. (3·54 in.)
90 carriages for guns of 95 mm. (3·74 in.)
175 carriages for guns of 155 mm. (6·10 in.)

From the foregoing list it would appear that the largest gun attempted by the Cail company, at all events on the De Bange system, was the ill-fated piece of ordnance of 340 mm. (13·39 in.), which figured at the Antwerp exhibition, and came to an untimely end when it was tested subsequently. As a matter of history it should be placed on record that the Anciens Etablissements Cail were among the most active cooperators with the French government during the siege of Paris in 1870. It was not only war material which they labored continuously to supply, for their shops were full of machinery required to supply, as well as might be, the wants of a hard-pressed population during that trying time. It was they who in an incredibly short space of time constructed the mills in which grain was ground into flour by the government and distributed among the inhabitants of Paris. During the siege, with a delay of less than four months, they furnished to the government of national defense 67 mitrailleuses, 110 breech-loading Reffye bronze guns, 1 apparatus projecting petroleum, and a large quantity of miscellaneous material, and especially for ammunition.

The ordnance shown by the Cail company at the Paris exhibition comprised guns of all calibers, from mountain batteries 80 mm. bore to a cannon of 320 mm. (12·60 in.), complete upon its mountings, and intended either for coast defense or for naval purposes; in addition to this was a special type of rapid-firing gun. All these, excepting the last named, were on the De Bange system, and showed the latest modifications that had been introduced. Before proceeding to describe them in detail, we will pass rapidly in review the different types, adding a few words upon the special characteristics of each.

The mountain guns were all of the same caliber—80 mm.—and corresponded in their dimensions to the regulation French weapon; the general arrangements of mounting, etc., were also the same. The leading particulars of this gun are as follows:

Diameter of bore between lands	80 mm. (3·15 in.)
Diameter measured to the bottom of grooves	81 mm. (3·19 in.)
Total length of gun	1 m. 200 mm. (47·24 in.)
Length in calibers	15
Number of grooves	24
Total weight of gun	231 lb.
Weight of projectile	13·2 lb.
Weight of powder charge	0·88 lb.
Initial velocity	820 ft.

The carriage differs chiefly from the regulation French type in the arrangement of the springs for checking the recoil; both gun and carriage can be taken into parts for the convenience of transport, the whole being mounted on three mules. The ammunition boxes are loaded in pairs on mules, and each box contains seven rounds. The following are some further particulars of this weapon:

Height from ground to centers of trunnions	29·73 in.
Angle of recoil	33 deg.
Diameter of wheels	35·67 in.
Width between wheels	26·77 in.
Weight of carriage without wheels	242 lb.
Total weight of gun and carriage complete	583 lb.
Greatest elevation above horizon	30 deg.
Angle of maximum depression	12 deg.

Of field guns two types were shown; one of very light construction intended especially for mountainous districts, the other corresponding to the regulation field gun of the French army. The following are particulars of the former material:

Diameter of bore between lands	3·15 in.
Diameter to the bottom of grooves	3·19 in.
Total length of gun	59 06 in.
Total length in calibers	18·7 in.
Number of grooves	24
Total weight of gun	363 lb.
Weight of projectile	13·2 lb.
Weight of powder charge	1·1 lb.
Initial velocity	951 ft.

The carriage is built of steel plates, as well as the limber; the ammunition wagon contains 18 projectiles in six cases, and 20 cartridges in five leather cases.

The following are some additional particulars:

Height from ground to center of trunnions	33·86 in.
Angle of recoil	30 deg.
Diameter of wheels	45·27 in.
Distance apart of wheels	43·21 in.
Weight of carriage	528 lb.
Total weight of gun and carriage	902 lb.
Maximum angle of elevation	25 deg.
Maximum angle of depression	10 deg.
Weight of limber loaded	770 lb.
Weight of ammunition train	792 lb.

The heavy type of field gun corresponds almost exactly with the regulation French weapon, and has the following dimensions:

Diameter of bore between lands	3·15 in.
Diameter between bottom of grooves	3 19 in.
Total length of gun	89·76 in.
Total length in calibers	25·5
Number of grooves	24
Total weight of gun	925 lb.
Weight of projectile	13·2 lb.
Weight of powder charge	3·3 lb.
Initial velocity	1,574 ft.

The carriage is in all respects similar to that of the French regulation pattern, all but a few quite insignificant details. The limber is entirely of steel excepting the pole and the wheels. It carries 30 projectiles in six boxes, and 30 powder charges in six leather cases; the various tools and spare pieces are contained in two drawers. The ammunition wagon, which is also of steel, has a capacity double that of the limber; it is also so arranged as to carry a spare wheel and pole, as well as various tools.

Height from ground to center of trunnions	41·73 in.
Angle of recoil	30 deg.
Diameter of wheels	53·36 in.
Distance between wheels	56·10 in.
Weight of carriage	1,117 lb.
Total weight of gun and carriage	2,101 lb.
Maximum angle of elevation	25 deg.
Maximum angle of depression	6 deg.
Weight of limber loaded	1,551 lb.
Weight of ammunition train loaded	2,178 lb.

The following are particulars of the ammunition employed with these guns:

A. Shrapnel—

Number of balls	23
Weight of shell empty	12·38 lb.
Weight of exploding charge	0·34 lb.
Weight of fuse	0·48 lb.
Total	13·20 lb.

B. Case shot—

The case shot consists of a steel plate shell and of a

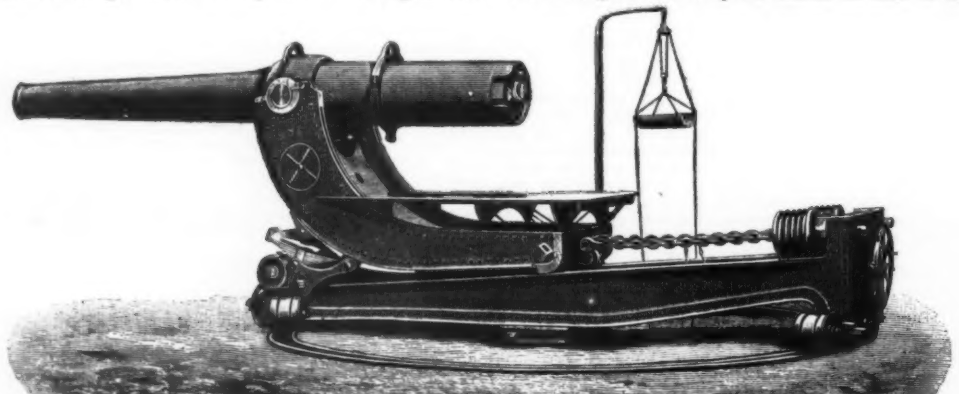


FIG. 1.—DE BANGE COAST DEFENSE GUN (9·45 IN. CALIBER) MOUNTED ON CARRIAGE.

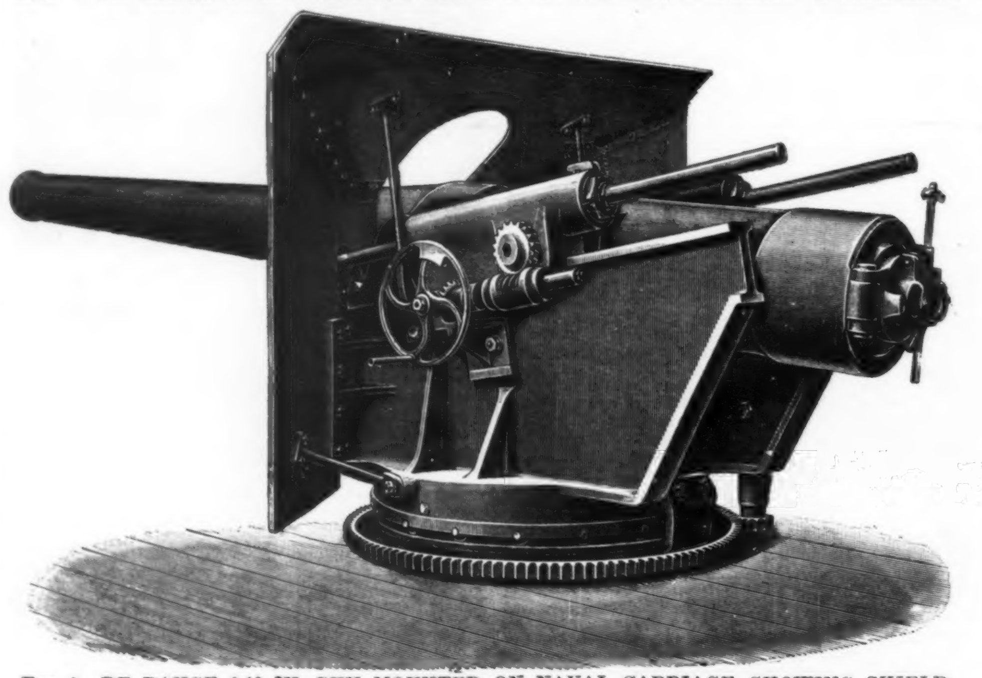


FIG. 2.—DE BANGE 6·10 IN. GUN MOUNTED ON NAVAL CARRIAGE, SHOWING SHIELD AND BRAKE GEAR.

number of hard lead balls separated by cast iron disks made so as to break up on striking. In the head of this projectile is placed a double-effect fuse, timed for thirteen seconds, which corresponds to a range of 4,000 meters.

Number of lead balls	105
Number of cast iron segments	36
Weight of projectile	10·9 lb.

C. Mitraille case shot—

This class of projectile consists of a zinc shell filled with balls of hardened lead, the spaces between them being filled with melted sulphur.

Number of balls	85
Weight of projectile	12·21 lb.

The siege guns exhibited consisted of one of 120 mm. (4·72 in.) and another of 155 mm. (6·10 in.) The former was of regulation French pattern; as regards its dimensions it was as follows:

Diameter of bore between lands	4·72 in.
Diameter of bore to bottom of grooves	4·79 in.
Total length of gun	10 ft. 8 in.
Total length in calibers	27
Number of grooves	36
Total weight of gun	4,950 lb.
Weight of projectile	39·68 lb.
Weight of powder charge	11 lb.
Initial velocity	1,672 ft.
Height from ground to center of trunnions	70·87 in.
Angle of recoil	33 deg.
Diameter of wheels	61 in.
Width between wheels	59 in.
Weight of carriage	2,992 lb.
Weight of hydraulic brake	660 lb.
Total weight	4,202 lb.
Maximum angle of elevation	30 deg.
Maximum angle of depression	15 deg.

The mounting of this gun is intended for fixed position, provision being made for placing it on wheels to facilitate transport.

Of ordnance for coast defense and naval service, three types may be mentioned; those of 155 mm., 270 mm., and 320 mm. (6·10 in., 10·63 in., and 12·60 in.) The 155 mm. coast gun is 35 calibers in length, and is intended to give very high initial velocities. As the gun is fired by the man who stands directly behind the breech, an obturating fuse is necessary. The device employed is on the De Bange system—a friction fuse which can only be fired when the breech is quite locked, protection being secured by means of a safety bolt. The following are the particulars of this gun:

Diameter of bore between lands	6·10 in.
Diameter of bottom of grooves	6·17 in.
Total length of gun	17 ft. 7 in.
Length in calibers	35
Number of grooves	45
Total weight of gun	10,450 lb.
Weight of projectile	110 lb.
Weight of powder charge	55 lb.
Initial velocity	2,132 ft.
Height of trunnions above floor	43·31 in.
Maximum recoil	25·59 in.
Maximum angle of elevation	25 deg.
Maximum angle of depression	10 deg.
Total weight of mounting	6 tons.
Weight of shield	1,470 lb.

The carriage is of cast steel, with a central pivot and hydraulic brake. A device is introduced within the frame for taking the strain off the carriage and deck of the ship when the latter is in a seaway by means of Belleville springs, which are compressed by the weight of the gun if rolling occurs. A shield made of chrome steel is attached to the forward part of the carriage, to protect the men serving the gun. The common shell fired from this gun is of cast iron, with a percussion fuse in the head. The weights are as follows:

Weight of empty shell	73·1 lb.
Weight of bursting charge	3·25 lb.
Weight of fuse	0·484 lb.
Total weight	76·834 lb.

The projectile used for firing test charges is a cast iron cylinder weighing 110 lb.

The mortar of 270 mm. (10·63 in.) corresponds in dimensions with the standard French mortar for coast defense. The following are some of its principal particulars:

Diameter of bore between lands	10·63 in.
Diameter of bore at bottom of grooves	10·76 in.
Total length of gun	11 ft. 1·8 in.
Total length in calibers	12·5
Number of grooves	80
Total weight of gun	6 tons.
Weight of projectile	374 lb.
Weight of powder charge	33 lb.
Initial velocity	984 ft.
Height from ground to center of trunnions	65·72 in.
Length of carriage	99·43 in.
Weight of carriage	6 tons.

The mounting for this mortar is, of course, intended to be fixed; it can, however, be mounted on wheels for convenience of transport.

The gun of 320 mm. (12·60 in.) was the largest piece of ordnance shown by the Cail company at the exhibition. It was mounted on a coast defense carriage, but is adapted also for naval service. This gun is built upon the latest modification of the De Bange system, in which the biconic arrangement of tubes is reduced to very limited proportions. The following are the leading dimensions of the gun:

Diameter of bore between lands	12·60 in.
Diameter to bottom of grooves	12·72 in.
Total length of gun	40 ft. 10 in.
Total length in calibers	39
Number of grooves	120
Total weight of gun	47 tons.
Weight of projectile	880 lb.
Weight of powder charge	440 lb.
Initial velocity	2,132 ft.
Maximum range	12·5 miles.
Height from ground to center of trunnions	11 ft. 5·7 in.
Maximum recoil	79·74 in.
Maximum angle of elevation	30 deg.
Maximum angle of depression	12 deg.
Weight of mounting complete	54 tons.

The Cail company, not possessing any firing ground of their own, asked and obtained the permission of the French War Department to have this gun tested at the State Polygon at Calais, before it was sent to the exhibition. The tests were made on May 7, 8, and 9, 1889, by a government commission, and from these experiments it was found that the energy imparted to the projectile on leaving the gun was 8,622 metric tons. This energy was sufficient to have penetrated an armor iron plate at the muzzle of the gun 35·43 in. in thickness, or 29·53 in. thick at a range of 1,500 yards. At the muzzle of the gun the shot would have penetrated a steel plate 23·62 in. thick, and one 19·69 in. thick at a range of 1,500 yards.

We give views of the representative types of artillery made by the Cail company. Fig. 1 illustrates a coast defense gun of 240 mm. (9·45 in.), mounted on its carriage and in firing position. Fig. 2 is the gun of 155 mm. (6·10 in.) on a naval carriage, showing the position of shields and hydraulic brakes. Fig. 3 is a general view of the great 340 mm. (13·39 in.) gun and carriage, the former being in firing position; and Fig. 4 is a 155 mm. (6·10 in.) rifled mortar mounted on its carriage, which is available for transport.—*Engineering.*

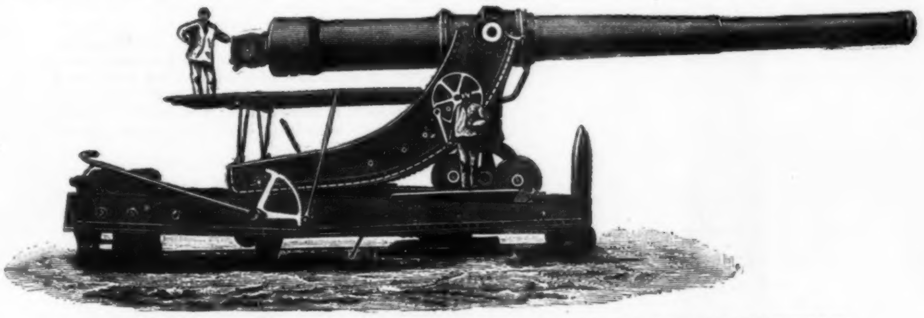


FIG. 3.—34 CENT. (13·39 IN.) GUN AND CARRIAGE IN FIRING POSITION.

FIG. 4.—MORTAR 6·10 IN. CALIBER AND TRANSPORT CARRIAGE IN FIRING POSITION.

The carriage on which this gun is mounted is of the French standard pattern and is built of steel, but the gun can also be placed on any fixed mounting if it is desired to use it in a fort. The projectiles fired from this gun are common shell and shrapnel; the former is of cast iron with a percussion fuse in the head.

Weight of empty shell	37·4 lb.
Weight of bursting charge	1·8 lb.
Weight of fuse	0·48 lb.
Total weight	39·68 lb.

The shrapnel consists of a steel plate envelope filled with hard lead balls separated by cast iron stars. The bursting charge is placed in the head, and to the point is fitted a combination fuse timed to thirteen seconds, corresponding to a range of 5,000 yards.

Number of lead balls	252
Number of iron stars	120
Weight of shrapnel	38·37 lb.
Weight of bursting charge	0·62 lb.
Weight of fuse	1·28 lb.
Total weight	40·27 lb.

The howitzer of 6·10 in. bore was of the pattern known in the French artillery service as the short 155 mm. Its dimensions are:

Diameter of bore between lands	6·10 in.
Diameter of bore at bottom of grooves	6·17 in.
Total length of gun	94·48 in.
Length in calibers	15·5
Number of grooves	48
Total weight of gun	2,310 lb.
Weight of projectile	88 lb.
Weight of powder charge	6·6 lb.
Initial velocity	984 ft.
Height from ground to center of trunnions	44·5 in.
Weight of carriage	2,475 lb.

THE MORGAN ENGINEERING WORKS.

THOSE who take pleasure in examining a modern high class engineering establishment will do well to visit the Morgan Engineering Works, of Alliance, O. The most improved facilities for handling all classes of material are used, and the shop system permits business to be carried on with little of the disagreeable interruptions so disastrous in badly arranged shops. To facilitate the management, a central telephone system is being introduced in such a way that any foreman can speak with any other foreman or with the main office without leaving his department, call bells being placed at several convenient points in each shop. In the tool room is an annunciator system arranged in such a way that a workman can obtain tools without leaving his work. Standard gauges are used for all work, and are compared frequently with permanent standards kept in glass cases in the tool room.

One of the most interesting changes going on in this shop is the concentration of boiler and engine power. A new boiler house and a stack 125 ft. high are to be built, and in this building will be placed all the boilers. It will be adjacent to a new engine room, which will contain all of the engines, the power being transmitted by means of electricity, which will drive motors at various points. Little or no shafting will be used.

This concern purchases nearly all of its machine tools, only a few special ones being made at the shops. Among the tools noticed are machines from all of the prominent makers.

The capacity of the shops is about twenty tons of machinery per day. This is based on the output of last year. They are now building three overhead traveling cranes for the Dixon Manufacturing Company, to be used for a new foundry. Two of these are 25 ton and one of 10 ton capacity, with a 57½ ft. span, the power being conveyed to the crane by a square shaft.

They are also building a 20 ton crane, 58 ft. span, for the Lackawanna Iron and Coal Co. and a 50 ft. 30 ton overhead crane for the Illinois Steel Company, for a new plate mill at South Chicago. They have just completed one 78 ft. 25 ton crane of the same pattern over the rail train at the same mill, two overhead cranes for the Pennsylvania Railroad shops at Altoona, driven by electricity, four traveling cranes for the Niles Tool Works, 20 tons capacity, two of which are 50 ft. span and two 30 ft., and two 35 ft. cranes for the Watervliet Arsenal, Troy, New York. These cranes have a travel of 562 ft. and are 50 ft. span. The square shaft which drives these cranes is 562 ft. long and weighs 15 tons. A 10 ton traveling crane for Russell & Co., manufacturers of agricultural machinery at Massillon, O., has lately been finished. The span is 37 ft., and the power is derived from a square shaft. Also there are being made three large plate mill shears for cutting plates 120 in. wide, and twelve hydraulic jib cranes 10 tons capacity; also a hammer weighing 860 tons, and a 120 ton traveling crane, with overhanging jib, 52 ft. span, to operate with this steam hammer. Probably the most interesting tool now building at this shop is a crane of 150 tons capacity for the U. S. government. There are also building four 35 ton hydraulic ingot cranes and two 50 ton ladle cranes with automatic motion.

The 150 ton crane has been two years under construction. The span is 62 ft. from center to center, with a cross travel of 44 ft. and a longitudinal movement of 112 ft., having a clear lift from the floor of 41 ft. It is just finished, and has been erected and put in position at these shops for exhibition. It has six changes of speed for hoisting and two for travel, as well as two changes for trolley travel. The Morgan Engineering Works are entirely responsible for this crane. They accepted the contract under rigid specifications which others refused to accept. It will be erected in the 16 inch gun shop of the United States Navy Yard at Washington. The size of this undertaking may be appreciated from the number of drawings, of which there are 85 sheets, 42 × 27 in. It will require about fourteen cars to ship the entire crane.

The offices of this company are among the finest in this country. About 26 draughtsmen are employed, working under conditions with regard to light and ventilation that are unexcelled anywhere. The drawings are made in pencil and traced on parchment pa-

per, from which blue prints are made, the tracing being filed away in drawers provided for that purpose. The arrangement of the wardrobes and lavatories connected with these drawing rooms is worthy of emulation. Each man has his individual box, as is customary in most gymnasiums. Nearly all of the draughtsmen are apprentices from the shops, and the officers say that the most satisfactory results are got from the encouragement of all young men at their works.

The shops are lighted by the electric arc light, and about 600 men are kept constantly employed. The enormous number of patterns made here can best be appreciated from the statement that 75 pattern makers are employed continually and that five large pattern store houses are found necessary. In these store houses there is a system of changing patterns and an arrangement of shelves and numbers which facilitate materially the foundry work. All the patterns ready for the foundry are placed in a large room by themselves, from which the foundryman selects according to his needs, which saves an enormous amount of time and considerably cheapens the work, because in that way castings of the same character can be made at the same time and suitable iron procured. Three new pattern shops of brick are now to be built. No one is allowed to enter these shops after dark, and if any one is found in there with a light of any sort, it is sufficient cause for a dismissal. The foundry is 350 ft. long by 60 ft. wide, with wings in addition, and contains two electric traveling cranes. The fans and elevators are also driven by electricity.

In the new dynamo room will be eight large dynamos which will drive motors of about 200 horse power in the aggregate. A new erecting shop 350 ft. long is soon to be built. In the machine and erecting shops are four traveling cranes, three of which are driven by electricity. One of the shops is now driven by a 20 horse power motor in a very satisfactory manner.

Among other things now being made here is an anvil weighing 360 tons. It is made in nine sections of 40 tons each, dovetailed together and clamped. There is also a cast steel ram weighing 35 tons for a hammer which weighs 860 tons. Recently constructed is a hydraulic steel shear for the Homestead Steel Works, which cuts ingots 42 × 23 in. when at a dull red heat. The hydraulic pressure used with the shear is 5,000 lb. per square inch, and the total pressure 130 tons. The head of the machine is held down by bolts 16 in. in diameter.

For the same works recently constructed are three plate mill shears having 11 ft. blades, the machines weighing 160 tons each.

Steel and mitis castings and phosphor bronze are largely used in the construction of all machinery. The dynamos are driven directly from the engine by means of a very satisfactory friction pulley consisting of a rubber band arranged on the smaller pulley which can be forced against the driving wheel of the stationary engine.

The policy of Mr. T. R. Morgan, Sr., the founder of these works, and also founder of the Solid Steel Works adjacent thereto, is to bring up around him a class of young men who can take from his shoulders the load of responsibility and carry on under his supervision the business which he has started. Four of his sons are already at work in the shops superintending the work. One is a chief draughtsman and another an electrician. They have all received a good education and have been fitted for the positions which they occupy. Another son, not yet graduated, is to enter the same business, filling a position for which he is being educated.

Other young men who have served their term in the shops are rising through the drawing rooms and test departments to positions of prominence, either here or in other establishments of like character.—*Railroad Gazette.*

GREAT TOWER FOR LONDON.

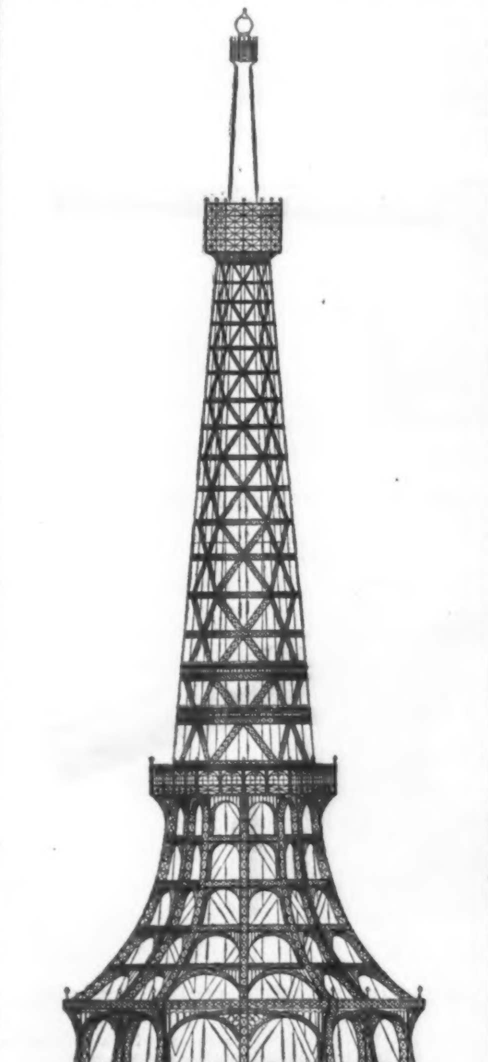
THE tower illustrated by the accompanying engraving is that designed by Mr. Henry Davey, M. Inst. C.E. In his description, Mr. Davey says: The tower to be steel, hexagonal in plan. There are twelve principal members, consisting of taper tubes, braced externally by diagonal and internally by horizontal bracing. The center space left by the horizontal bracing to be occupied by the lifts. The structure takes the form of a spire above the first stage, 380 ft. from the ground; below that the straight lines of the spire are broken by buttresses having a network of lattice girder work with curved outlines, for artistic effect, and incorporated with the principal members, bracing and re-enforcing them. The stability of the structure against wind pressure is secured by a large base, and by loading the principal members with masonry, as shown on the drawings.

For wind pressure the total area taken is that included in the largest outline of the tower at 56 lb. per square foot. It is calculated that the tower would be completed with 8,000 tons of steel, the stress on the steel not exceeding 7¼ tons per square inch with a wind pressure of 56 lb. per square foot. On the ground floor there is a space of 70,000 square feet. It is proposed to make use of that for a winter garden, and from there visitors would enter the lifts. In the basement would be placed all the machinery for working the lifts and electric lighting. The boilers would be used for heating the winter garden, as well as for working the engines and pumps. Various ornamental fountains would be placed about in the garden, all worked from the pumping engines used for the hydraulic lifts. There would be two lift stages, one 380 ft. from the ground, and the other 980 ft. At the first stage there would be three floors, giving a total area of 58,000 square feet. At the second stage there would be four floors, giving a total area of 14,000 square feet. The floor space of each lift cabin would be 250 square feet. There would be a broad staircase outside the lift wells reaching from the ground to the top stage, also a staircase in the remaining portion of the tower, reaching to the ball, 1,350 ft. from the ground.

It is proposed to have thirty-six electric arc lights on the exterior of the tower, as well as incandescent lamps in the various rooms and in the winter garden; also a very powerful electric light in the ball at the very top of the tower, 1,250 ft. from the ground. Security is provided by the fact that the principal members of the tower extend deep into the ground through the foundation.

Lifts.—Designs for two kinds of lifts have been made. One is a reverse pulley block hydraulic balanced lift. In this system there are six complete lifts—four from the bottom to the first stage, and two from there to the top. The Armstrong reverse pulley block is well known and largely used in lift work. The original parts of the lifts, which have been designed for the special purpose of the tower, are in the mode of balancing with a double system of cabins, reducing the lift of each (as was done in the Edoux lift of the Eiffel tower), and in the safety appliances for the cabins. Each lift consists of a double-acting hydraulic cylinder, having a piston with a rod extending out at each end, and each rod taking hold of a crosshead carrying four pulleys of a reverse pulley block, the other four pulleys of the block being carried in a frame fixed to the tower. The rope from the top block is led to the top of the lift over a pulley, and is attached to a cabin which rises and falls through half the height of the lift from the top. A rope from the bottom block passes over a pulley a little more than half way up the lift, and takes hold of a second cabin which traverses the lower half of the lift, the two cabins coming together in the middle, thus reducing the lift of each to one-half of that of a single lift. The upper lift cabins have a course of 300 ft. each, and the lower lift ones of 190 ft. each. The pulley blocks being eight to one, that makes the stroke of the piston of the upper lifts 37·5 ft., and that of the bottom lifts 23·75 ft.

Summary.—Tackle lifts: Four to the first stage,



DESIGN FOR A GREAT TOWER FOR LONDON. HEIGHT, 1,350 FEET.

380 ft. high, and two from the first stage to the top. Four bottom lifts: Speed of lift, 200 ft. per minute; time of double lift, two minutes; duration of stop, four minutes; total time, six minutes; number of passengers per cabin, 50; number of passengers up and down, per hour, 2,000. Two top lifts: Speed of lift, 200 ft. per minute; time of double lift, three minutes; duration of stop, four minutes; total time, seven minutes; number of passengers per cabin, 57; number of passengers up and down, per hour, 1,000. There is ample room for increasing the capacities of these lifts to sixty, or even seventy, persons per cabin, should it be considered that a greater number of passengers must be provided for. The second design is for a direct-acting hydraulic balanced lift. The lifts proposed are direct-acting hydraulic with a peculiar system of balancing, the balance constituting a safety appliance. There are three complete lifts—two to the first stage, and one from there to the top stage. The top lift consists of two columns, each carrying four cabins, 150 ft. apart. Each column has a stroke of 150 ft. One column of cabins makes its up stroke simultaneously with the down stroke of the other, so that at the end of the stroke the bottom cabin of one column will be down at the bottom floor, and the top cabin of the other column at the top floor. Passengers going up or down have simply to enter or change cabins at every time of stopping of the lift. There are two doors to each cabin, one to enter and the other to leave by, so that there cannot be any confusion or mistake. There will be an attendant in each cabin. The bottom lifts are similar to the top ones, except that there are only three cabins to each column, and the stroke is only 126·6 ft.

Summary.—Bottom lifts, total height, 380 ft.; stroke of lift, 126·6 ft.; duration of journey, 1¼ minute; time of changing passengers, 2 minutes; floor area of each cabin, 250 square feet; number of passengers, seventy per cabin; number of passengers per journey, as the lift is double, 140; number of lifts per hour, nine; number of passengers per hour for each of the two lifts, 1,260; total passengers, both up and down, per hour to the first stage, 2,520. This system of lifts is capable of carrying a large number of passengers in a given time at a low speed of lift, securing additional safety by slow speed and long intervals for changing passengers. Let each cabin take seventy passengers, and let the lift be made in 1¼ minutes, then allowing two minutes for each change, nine journeys would be made in one hour, and, as the lift is double, 1,260 passengers would be taken both up and down per hour. To the first stage—380 ft.—there are two lifts, and from there to the top one lift. The lift capacity would therefore be 2,400 persons both up and down at the same time per hour to the first stage and 1,200 to the top.

Pumps.—In both systems of lifts described, the work to be done is simply that of conveying the full complement of passengers and overcoming the friction of the machinery.

Direct-acting hydraulic balanced lifts.—For the two bottom lifts, carrying 2,520 passengers per hour, 100 horse power; for the top lift, conveying 1,260 passengers per hour, 90 horse power; total, 190 horse power.

Tackle lifts.—For the four bottom lifts, conveying 2,000 passengers per hour, 80 horse power; for the two top lifts, conveying 1,000 passengers per hour, 76 horse power; total, 156 horse power. It will be seen that in both systems of lifts the cabins balance each other, and that one is up when the other is down, so that if there are the same number of passengers coming down as going up, the only power required for the lifts would be that required for the friction. It would be possible to work the lifts from a low level tank, taking care to only run when each up and down cabin has its complement of passengers; the power required would then be only one-fourth of the power provided.—*The Engineer.*

SAILING SHIPS.

IT was not infrequently predicted that the building of sailing ships would cease in the event of the projected Suez Canal being brought to a successful termination, and that these most notable specimens of man's power over natural phenomena, which walked the waters like animated beings, would soon be as extinct as the dodo. The prophets based their sapient utterances on the purely gratuitous supposition that the trade from the East Indies, China, Japan, and the antipodes would be diverted from the sailing ships following the old route around the Cape of Good Hope, and attracted to the steamships using the shorter route up the Red Sea. Shareholders in sailing ships made haste to dispose of their depreciated investments, and to transfer their allegiance to steam. Sailing ship shares consequently fell lower than they had ever before been. Every one did not share the belief of Robert Stephenson that the proposed waterway would prove to be a stagnant ditch, which would cost so much to dig and to keep in order that it could never be remunerative. The instinct of the traders, however, was not entirely at fault; even though they raised many objections to it in the first instance, when De Lesseps worked hard to enlist their sympathies and entice their capital in order to make his brilliant conception an established fact. Palatial ocean liners and humble ocean tramps have availed themselves of this short cut in increasing numbers, and still the sailing ship's extended pinions are to be seen on every sea. Within three years from the date of the rush for shares in steamships, there was a radical change for the better for the owners of sailing ships. Sailers having a registered tonnage varying between 1,500 and 2,000 tons were building at about £20 per ton, which was more than three times the figure at which the highest class ships changed hands in 1870. It would appear that steam has not caused such a sensible diminution in the number of sailing ships in existence as might justifiably have been assumed. It has, however, somewhat determined the size of the sailing ship of the future. There are sailing ships afloat to-day which a few years ago would have been considered too unwieldy to be handled under canvas. Fifty years ago there were only about 150 sailing ships in the British mercantile marine over 500 tons register. Even the smallest craft of that time were far in advance of the ships in which the hardy Vikings did or died. One of these ancient vessels, unearthed in Norway in 1880, was 72 ft. long, 17 ft. beam, and probably drew 5 ft. of water. She had twenty benches for rowers, a step for a mast to be shipped at will, and it was evident that she was unable to do anything against adverse gales. The old Brotherly Love, in which the illustrious circumnavigator, Captain Cook, is said to have sailed, is an example of the well built craft of the last century. She was launched in 1764, and sank, after collision, in 1878, at the good old age of 114 years. A model of her has recently been exhibited. Last year was the jubilee of George Smith's City Line, and Mr. Smith, speaking at a dinner held in honor of the event, pointed out that his firm had owned 52 sailing ships during the past fifty years, with a tonnage of 49,000 tons, or rather less than 1,000 tons each ship on the average. The favorite size of sailing ship has gradually increased from 1,000 tons in 1860 to 1,300 tons in 1870; 2,000 in 1880; and now there are about 20 ships in existence of over 2,500 tons, and some of them over 3,000 tons register! Ship owners and brokers evince an apparently pronounced preference for such leviathans, but underwriters have not yet been educated up to them, and are not very loud in praise of the increased risk consequent on this new departure. The 3,000 ton sailing ship would appear to be suitable only for certain trades, and in many ports the dock accommodation would be quite inadequate for their requirements in case of damage to their hulls below the water line. The supplanting of wood by iron has been beneficial to this country. It was, however, a work of time, and many deep-rooted prejudices had to be extirpated. A chief constructor at one of the royal naval dock-

yards is reported to have said to Scott Russell, "Don't talk to me about iron ships, it is contrary to nature." In 1838 the historical steamships the Sirius and the Great Western were built; and their passage across the North Atlantic utterly falsified the prediction of that man of many titles and much learning, Dr. Lardner. He was of opinion that it would be as easy to make a voyage to the moon as across to the United States in a new-fangled steamship. It is always awkward to prophesy before you know. The first sea-going iron sailing ship was launched that same year, and appropriately named the Ironsides. Even after the seaworthiness of iron ships had been proved up to the hilt, there still remained to be wrestled with the important error introduced into the direction of the compass needle by the local attraction and repulsion exerted upon it by the enormous mass of iron in the ship's hull. The deviation of the compass varying with every direction of the iron ship's head, with her degree of heel, and with her geographical position, seemed an insurmountable barrier in the way of iron shipbuilding. Suitable means were devised for correcting this insidious error, and its laws subjected to rigid mathematical analysis. Seamen are greatly indebted to Sir G. B. Airy, who not only made easy the working of the longitude by lunar distances, but also corrected the compasses of the Ironsides, and cleared away the tangle for future investigators. Iron appears likely in turn to be superseded by steel, which is much lighter. For example, the steel steamship Servia would have weighed 600 tons more if constructed of iron on the same lines.

Of late years it seems to have been the good fortune of the British nation to be shipbuilders to the world at large. Should a yacht of unusual form and dimensions be required for a Russian potentate, a transatlantic steamship for a German company, or an immense sailing ship for French shipowners, it is generally this country that builds them. Our second hand sailing ships are also greedily bought up by foreigners. Scandinavians are the principal customers for wooden ships that have nearly run off their class, but may, under their flag, be useful yet for the coal and timber trades. Germans prefer our iron ships, which are not much the worse for wear, in order to employ them in the East India and China trades. United States shipowners would gladly purchase iron ships from us, but the protection system of their country does not permit them to buy in the cheapest market. We have seen at Liverpool several well modeled large iron ships that were built in the United States, but wooden vessels are still the principal output of North American shipyards. Such wooden ships cannot compete on favorable terms with more modern iron ships, and obtain less rates of freight in their own home ports, such as New York and San Francisco.

The period when the fastest sailing ships were built in the United States is not very remote. The late James Baines, of the well-known Liverpool Black Ball Australian Line, had the Lightning built by Donald McKay, at Boston, U. S., and she was able to show a clean pair of heels to any ship on her route. The designers of American clipper ships were not handicapped by tonnage laws such as were in force over here up to the year 1854, and which led to the building of deep, narrow ships, that were unable to keep the sea from want of stability and other inherent vicious qualities. The old builder's measurement was essentially a rule of thumb based upon the length and breadth of a ship. It was obtained by the equation: Tonnage = (Length − ⅗ Length) + Breadth + ½ Breadth ÷ 94, where it was erroneously assumed that the depth was as a rule equal to half the breadth. Ship owners not unnaturally wished for ships with large cargo-carrying capacities, and small nominal tonnage on which to pay dues, and shipbuilders perforce obeyed their behests. The advent of the American clipper was for a time disastrous to the British ship-owning interest, for those splendid ships, with their lofty spars, enormous spread of canvas, and exceptional speed, obtained an almost absolute monopoly of the China tea trade to this country to the exclusion of our own ships. The order of events is entirely reversed now, and American authorities complain bitterly that, with the exception of their protected coasting trade, their ocean carrying trade is in the hands of foreigners. General J. S. Negley, speaking at the Eighteenth Annual Convention of the United States National Board of Steam Navigation, bewailed the fact that all the resources of their country did not secure to them a rightful share of the world's commerce, inasmuch as other nations perform their carrying trade, and regulate and control their mail facilities. He urged that this issue was one of far-reaching importance, and appealed to the pride and material interests of all classes of Americans. Shipowners and shipbuilders bestirred themselves, and British sailing ships were soon afloat to wrest the palm from the American intruders as they were called. So much was the form of these Yankee clippers admired, that the Admiralty sent down draughtsmen to take off the lines of two of them, the far-famed Challenge and Oriental, as they lay in dry dock. In 1850, the British clipper ship Stornoway, of 506 tons, was built, and was soon followed by a goodly fleet of similar sailing ships. The new class of ship was inferior in point of size to the Americans that they were destined to supplant. Until the year 1863 they were built of wood; but afterward were composite ships. Only one, the Lord of the Isles, of 770 tons, built in 1853, was an iron ship. The average tonnage of the British clipper fleet was 800, and only one, the Oberon, exceeded 1,000 tons. There is a yarn, dear to old salts, that Messrs. Green built the Challenger on purpose to beat the American Challenge, and that the British ship was staked against her antagonist. This at least is certain, that the Challenger raced home from Anjer against the Challenge, and made the passage in sixty-two days, beating the American clipper by two days. Another remarkable race was that between the Challenger, the Nightingale, and the John Bertram. The backers of the Challenger won the stakes, amounting to 20,000 dollars. A good example of the composite clipper is the famous Thermopylæ, which may often be seen in the East India Dock at the White Star berth of Messrs. Geo. Thompson & Co. This good old ship is the delight of all true lovers of a clipper sailing ship. She is 940 tons register, 212 ft. long, 36 ft. beam, and 21 ft. depth, and when under all plain sail on a wind, is the embodiment of a sailor's ideal. She made the passage from London to Melbourne in 60 days; and from China to London in 91 days! We saw the John Bertram and the Nightingale in the Surrey Commercial Dock in 1883, under the Norwegian flag, and the former foundered in 1885, while bound from New York to Europe with petroleum. *Sic transit gloria mundi.*

The Liverpool iron ship Liverpool, of 3,330 tons, is the largest sailing ship in the world. She is 333 ft. long, 48 ft. beam, and 28 ft. depth. Next to her comes the Palgrave, a model of which we saw recently at South Kensington, of 3,078 tons. The French ship Nord left the Tyne in the beginning of April with 5,000 tons of coal for Valparaiso. She is 318 ft. long, 46 ft. beam, 29 ft. depth to upper deck, and has a cellular bottom capable of holding 2,000 tons of water ballast. A sister ship, the Dunkerque, has been recently completed on the Clyde for the same owners. The Liverpool ship Three Brothers is the largest British wooden ship afloat. She is 2,936 tons register, and her dimensions are—length, 323 ft.; breadth, 48 ft.; depth, 31; and was built at Boston, U. S., in 1855.

The American wooden ship Rappahannock, lately launched, is the largest of her kind afloat. She is 3,053 tons register, 287 feet long, 49 feet beam, and can spread 15,000 yards of canvas. Seven hundred and six tons of Virginia oak and 1,200,000 feet Virginia pine timber were used in her construction. She has four masts, yellow pine decks, and a long poop extending to the mainmast, which is 89 feet long and 38 inches diameter. Her foremast is 6 feet shorter than the main, but of the same girth, her main topmast is 58 feet, and main topgallant mast 71 feet long. Her mainyard is 95 feet, upper and lower main topsail yards 87 feet each, lower main topgallant yard 70 feet, upper main topgallant yard is 64 feet, main royal yard 53, and her main skysail yard 43 feet long. Her lower masts are of Georgia pine, her other spars are of Oregon pine, and she has an innovation in the shape of a steel bowsprit without jibboom. Double topsail yards were first fitted to the American four masted sailing ship Great Republic, the then largest sailing ship in the world. The Royal Charter was the first British ship to adopt double topsails, without which it would be almost impossible to sail the 3,000 ton sailing ships of the present day without a large increase in the number of seamen carried. Her mainmast was 75 feet from deck, masthead 20 feet, main topmast 65 feet, main topgallant mast 32 feet, and main royal mast 24 feet long. Her main yard was 101 feet, lower topsail yard 92 feet, upper topsail yard 85 feet, topgallant yard 65 feet, and royal yard 50 feet long. Her spread of canvas was 15,000 yards. Hence it will be seen that the Royal Charter was more heavily sparred than the Rappahannock, which is said to be the most heavily sparred ship under the stars and stripes. The Lightning was 2,093 tons register, 245 feet long, 44 feet beam, 23 feet depth, had bulwarks 7½ feet high, and a full poop of 90 feet. Her mainmast was 90 feet long and 38 inches in diameter; her main yard 95 feet. Some idea may be formed of the cargo capacity of the modern sailing ship when we mention that the Liverpool has just arrived at Dundee with nearly 20,000 bales of jute from Calcutta. The Rappahannock has taken 125,000 cases of refined petroleum on her maiden voyage from Philadelphia to Japan. The four masted iron ship Ellesmere, of 2,645 tons register, has carried one and a half million feet of sawn timber from Puget Sound, and almost the same number of gallons of oil from Philadelphia to Calcutta.

Sailing ships have made some remarkable runs in the Great Southern Ocean. The Lightning once came from Melbourne in 63 days. The James Baines, another Black Ball ship, in June, 1854, while running her easting down along the parallel of 43° S., ran 420 miles in 24 hours! There is not much to be wondered at in this, for we know she was run with main skysail set when a fresh gale was blowing, and she passed less well provided ships going the same way under reefed topsails! Those were the days of moon rakers, sky scrapers, and studding sails at every yardarm; whereas plain sail only is now the order of the day. She once was going 21 knots with her main skysail set, and had just taken in studding sails from skysail downward! The Red Jacket, in 1856, ran from 72° E. to 134° E. in 8 days. She averaged 334 knots daily in wicked weather, and one day was iced up forward. Passengers suffered severely from the cold, but the passage had to be made. Green's Blackwall liner Melbourne, Capt. R. Marsden, made 5,129 miles in 17 consecutive days while making her easting. Her best daily runs were 374, 362, and 352 miles. The Great Republic crossed the equator in the North Atlantic in 33° W., only 15 days 19 hours from Sandy Hook, so that large four masters were well able to make a passage even in those days.

America is the home of fore-and-aft vessels, which attain to extraordinary dimensions, despite their many drawbacks. Their lofty lower masts are very difficult to replace except in home ports, the great hoist of their sails, the size of gaffs and blocks, the slatting of the sails in light winds, the danger of lowering them in a squall, and the heavy head gear on which the masts depend, are all factors not to be lightly despised in handling them safely. American wooden four masted schooners are not uncommon, and they are gradually creeping up in size. There are the Elliot B. Church, 1,088 tons register; the Haroldine, 1,294 tons register; one of 1,300 tons, another of 1,400 tons register, and a dozen varying between 400 and 1,000 tons. Winslow has just built a five masted oak fore-and-aft schooner at Taunton, Mass. She has a carrying capacity of 1,800 tons, her length 265 feet, breadth 50 feet, depth of hold 25 feet. Her movable center board is 35 feet long, 7 inches thick, and drops 14 feet below the fixed keel. She draws 9 feet when empty and 20 feet when fully laden; has a steam winch to hoist her sails, heave up anchors, and work cargo gear; has a sail area of 7,000 yards, and her masts are all of the same height, the lower masts being 115 feet and the topmasts 56 feet long. It is reported that another five masted schooner is contemplated, with a carrying capacity of 3,800 tons, which will be the largest fore-and-aft schooner afloat. The United States has one iron three masted schooner, the Red Wing, of 415 tons register; and one iron four master of 1,600 tons, built at Wilmington, Del. She also owns several four masted wooden square riggers, as the Ocean King, of 2,386 tons, and the Frederick Billings, of 2,497 tons register. Americans are decidedly of opinion that a well modeled keel schooner can make as quick a passage as the average square-rigged vessel and at less cost to her owners; but the large fore-and-aft rigged schooner is peculiar to America, and will probably remain so.

Germany has lately launched some large iron and steel ships from her yards. The 2,800 ton ship Nereus was built by the Bremen Shipbuilding Company of German steel. Last September a large steel sailing ship of similar tonnage was launched at Genoa, being the first of her kind ever built in Italy. As yet, however, the British iron and steel ship builders have but little to fear from foreigners.

Space forbids further mention of others of the many large British iron and steel ships having a larger register tonnage than 2,300. We will conclude by noting that the greater number have been built at Liverpool, Southampton, Port Glasgow, and Belfast, in the order of their names; and that the sailing ship still survives.—*Nautical Magazine.*

THE VYRNWY AQUEDUCT TO LIVERPOOL.

THE supply of ample and good water to large cities has, in all the days of civilization that we know of, always afforded the engineer opportunities for the exercise of his most ambitious abilities, and has given rise to some of the finest monuments of the skill of the ancient builder. In the British Isles there are few works of water supply which have needed structures of the grander order either in the form of great masonry embankments or of aqueducts. It has fallen to the lot of the Liverpool Corporation to raise for that city the finest masonry dam in Europe, and it is now completing the construction of the longest aqueduct. Although this aqueduct is hidden throughout its length, and being made in these modern days of iron pipes presents no opportunities for works like the Roman Aqueduc du Gard, or of the aqueducts built in the seventeenth century to carry water to Paris, it is the largest in this country and presents some features of engineering interest and of some difficulty. We have in the SCIENTIFIC AMERICAN SUPPLEMENT given accounts of these remarkable works. From these accounts our readers will have become acquainted with their main features, and it will be remembered that the aqueduct crosses two watercourses, namely, the river Weaver and the river Mersey.

In the Liverpool Waterworks Act of 1880 was inserted a clause which made it necessary, says *The Engineer*, in case of difference between the engineer of the Corporation of Liverpool and the River Weaver Navigation Trust concerning the mode of crossing the Weaver, that the question should be referred to the decision of an arbitrator. Work of the kind has hitherto, both in this country and abroad, been carried out either within a coffer dam formed across the river or by sinking ball and socket jointed pipes in a trench excavated under water. In this case, however, and for crossing the Mersey, Mr. G. F. Deacon, M. Inst. C.E., the engineer of the works, proposed a different method, one which the use of modern mild steel made possible. The Weaver, where crossed, is over a hundred feet in width, and the Mersey over eight hundred feet wide. According to this method, which would avoid all interference with navigation during the progress of the work, the pipes to be sunk into the bed of the river were to be built up of steel plates riveted together. These, having been floated out into position over a trench sunk to a sufficient depth across the whole width of the bed, were to be sunk into their place by filling them with water. This method, and the details of its execution, seemed to be in every way satisfactory and exceedingly simple. In the case of the Mersey crossing, however, the interests, or supposed interests, of Warrington, and some other places higher up the Mersey, proved to be sufficiently powerful to make a reference to the Board of Trade necessary. The latter appointed Admiral Sir George Nares, K.C.B., to hold an inquiry and to report to them on the subject, with the result that the pipes were required to be laid at a depth not less than 20 ft. below the mean sea level. At this level the formation consisted of alluvial gravel and sand, and Mr. Deacon was reluctantly compelled to recommend that rather than attempt to lay the pipes in a trench at so great a depth in such material that a tunnel at much less depth should be constructed. This tunnel has proved to be one of the most difficult undertakings yet encountered in the construction of the whole sixty-eight miles of the Vyrnwy Aqueduct. The great depth to which it was demanded the pipes should be sunk was urged by the riparian authorities as being necessary on account of the possible future deepening of the river.

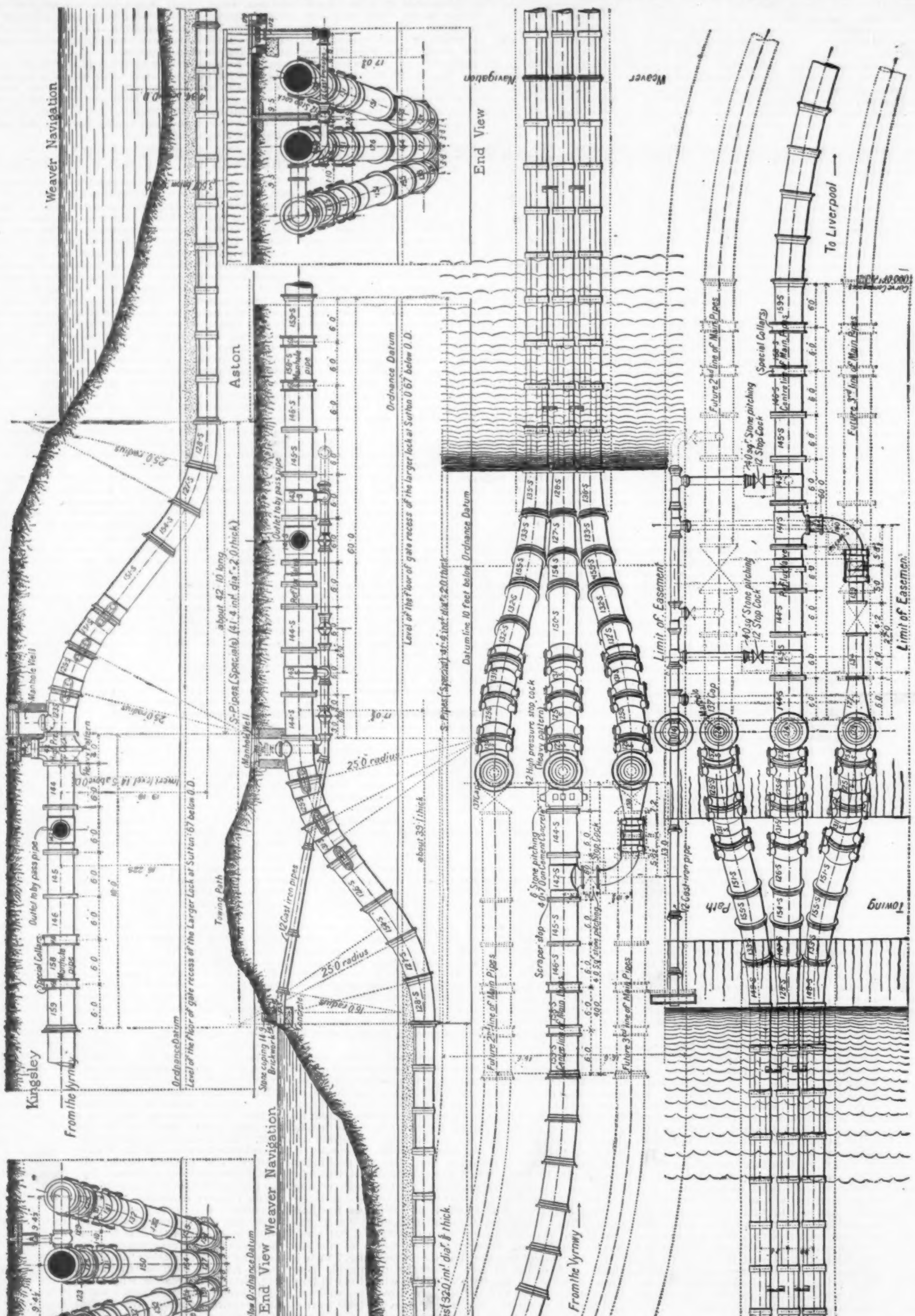
This, however, was always a highly improbable contingency, and has become more than ever so as a result of the construction of the Manchester ship canal, which is in effect a substitute for this portion of the river.

The work of constructing the tunnel is now making good progress under Mr. Greathead's process, as used by him in constructing the City and Southwark Subway, and it will probably be completed during this year. The Weaver Navigation Trustees also opposed the scheme for crossing the Weaver; but, after a long inquiry, the method briefly described above—and here illustrated—was allowed by the arbitrator, and has proved perfectly successful.

The Vyrnwy Aqueduct, where below ground but not in tunnel, will ultimately consist of three lines of pipes, but throughout the greater part of the whole length only one of these is at present being laid. In the case of the Weaver crossing, the Act of Parliament required that the three lines should be laid at one time. As has been shown in Mr. Deacon's report of 1888, there is no reason why the size of an aqueduct for a given discharge should not vary as circumstances may require, provided the hydraulic gradient is sufficient to overcome all resistances that may be interposed, as, for instance, by reducing the diameter at valves or at difficult river crossings, while there is much to be gained in reduced cost. The principle underlying the proof of this has been taken advantage of at the Weaver crossing, and the steel pipes there used have been made of smaller diameter than the rest of the main.

A section of the Weaver is shown, the section being given in two parts, with the object of giving the whole to the larger scale. From the engravings, which are from *The Engineer*, it will be seen that the large cast iron 42 in. main is gradually reduced in diameter in the curved parts near the junction with the smaller

built-up 32 in. steel pipes. On the curved short length cast iron pipes forming the upper bends trunnions are cast, and over these are placed connecting links, designed to prevent any separation of the pipes under the action of the water pressure, or as a result of any settlement. The engravings show the depth to which the pipes have been sunk and covered by concrete. The engravings so clearly show the many other details that it is unnecessary to describe them. Besides the plates and angles connecting the tubes together, a cast iron frame was fastened to the pipes near the ends, forming a rectangular plate, by means of which sheet piling at the two shores could be placed so as to make a water-tight joint when the pipes were sunk into their place. The object of this will be presently seen.



THE VYRNWY AQUEDUCT—THE WEAVER NAVIGATION CROSSING.

The three pipes were made at Warrington by the Pearson & Knowles Coal and Iron Company, and the temporary cast iron covers being placed on the ends, they were floated down the Mersey and up the Weaver Navigation some months ago. The trench was excavated chiefly by grabs, worked by steam cranes on barges. Two rows of sheet piling were previously driven along the river banks, at such distance apart as to allow the tubes—108 ft. in length—to be let down between them, the piles on either side forming a little dock, open to the river, and ready to receive the pipe ends. The Weaver at this part is from 14 ft. to 15 ft.

in depth, and the bottoms of the tubes had to be laid at a depth of 21 ft. On the seventh May last, the trench and the various preparations being ready, the pipes were rapidly floated into position, and their four ends attached by chains to four winches, ready to control their descent. The central pipe was then charged with sufficient water, and the three pipes lowered quickly and steadily into their position, the sinking occupying only about fifteen minutes. The pipes being thus in position, the next process was to drive sheet piling parallel with the previously mentioned piling and against the rectangular frames already mentioned, the space above the pipes and this frame being also filled in. The ends of the pipes were thus cut off from the river, and were within a little dock on either shore. Within these docks or dams the excavations for the ends of the cast iron pipes will be made, and the water being pumped out, the temporary cast iron covers will be removed from the ends of the steel tubes and the connections made. This being completed, the piling will be drawn, the cast iron frames removed, the space between the steel tubes and some depth above them filled with Portland cement concrete, and the bed and shores of the river made good. The contractor for the work is Mr. W. Winnard, Wigan.

THE ASPHALT INDUSTRY IN FRANCE.

BITUMEN is a mineral substance of a beautiful brilliant black, with slightly reddish reflections, that is met with either in a pure state or in a state of mixture with other substances. It is solid at a low temperature, and is ductile when slightly heated or rolled for a few moments between the fingers. It is liquid at about 50°, and it is relatively stable, since, when kept for several hours at a temperature of from 200° to 250°, it loses scarcely one per cent. of its weight. Its density is about that of water.

Asphalt is a calcareous rock that has been naturally impregnated with bitumen in consequence of a long continued contact with the latter or of a sudden eruption of the material from the interior of the earth through a fissure.

Asphalt of a good quality has the appearance of a soft rock at the temperature of summer and of a hard rock at that of winter. It has a fine grain, is dark chocolate colored, and is sometimes mottled black and brown. At a temperature of 50° or 60°, it may be crushed between the fingers. Exposed for a few hours to a burning sun, it disintegrates spontaneously into a brown unctuous powder. When we examine it under the microscope, we find that this rock is formed of small grains of limestone, each covered with a pellicle of bitumen and cemented together thereby. If a small piece of this material be heated, the bitumen that serves as a cement becomes soft and loses its agglutinating power. The molecules separate and fall into a powder resembling dark chocolate in color.

If, while it is still at a temperature of 80° or 100°, this powder is gathered up and strongly compressed in a mould, it assumes, on cooling, its former consistency, under its new form. It is possible, moreover, to repeat the same experiment upon the same material indefinitely. Each time, it will become soft through heat, will fall into powder, and then, when compressed anew, will assume its original hardness upon cooling. It is this singular property that has given rise to the style of pavement now so widely known as compressed asphalt.

Use of Asphalt.—The use of asphalt dates back to the remotest ages; some date it from the deluge. In fact, it is certain that the book of Genesis speaks of Noah's ark as having been coated with bitumen, and of the use of the material by the ancient Hebrews as a cement for the walls of the Tower of Babel. The asphalt lake, so famous in the Scriptures, contains large deposits of bitumen. This bitumen, which floats on the Dead Sea, is derived from numerous deposits situated at the bottom of the lake.

It is to the accidental ignition of petroleum or bitumen that Diderot's Encyclopedia attributes the burning of Sodom and Gomorrha. Not only the Hebrews, but also Assyrians, Arabs and Egyptians were acquainted with this inflammable and oleaginous material. The Egyptian mummies were preserved by means of this substance, which was spread upon the winding bandages and which possesses great preservative properties. But the use that was made of asphalt in the foundations of buildings and the construction of walls was much more important.

Among the ancient authors who mention asphalt, may be cited Herodotus, Diodorus Siculus, and Strabo.

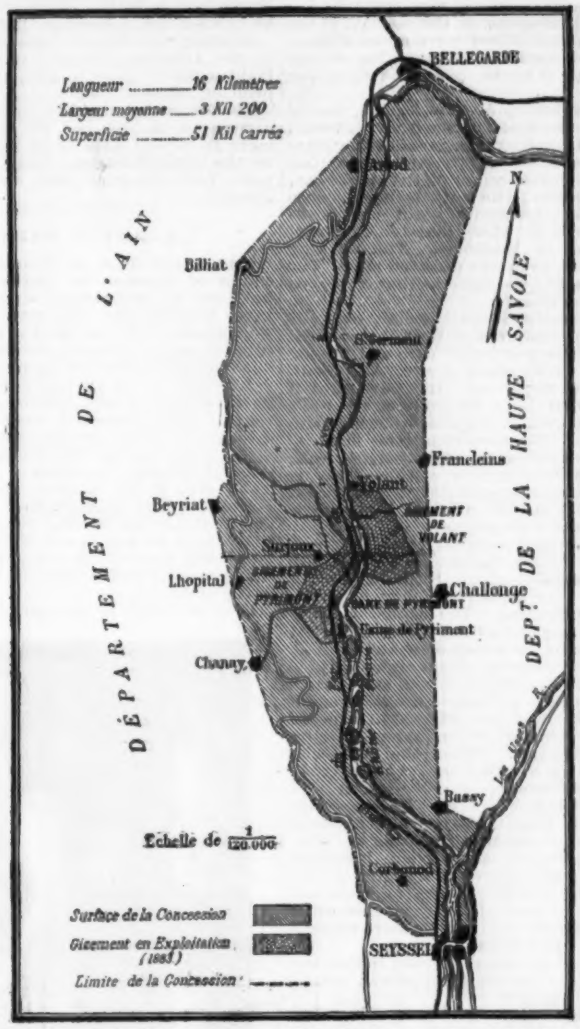


FIG. 2.—PLAN OF THE SEYSSEL ASPHALT MINES.

FIG. 1.—THE JAVEL ASPHALT WORKS AT PARIS.

The walls of Nineveh, the ancient capital of Assyria, were built with a mortar of asphalt; and Diodorus Siculus, a contemporary of Cæsar and Augustus, describes to us the processes that were used for asphalting the bricks with which the walls of that ancient city were constructed, "In order to bind the bricks," says he, "they were covered with a layer of hot asphalt, instead of simple tempered clay, and were arranged in courses; and, between each thirtieth course, a bed of reed canes was introduced. The asphalt used for the construction of these walls was obtained at the city of Io, situated at eight days' journey from Babylon, on a small river that empties into the Euphrates, and the water of which carries along a large quantity of asphalt in fragments."

The custom of coating the external and internal walls of the ground floor of houses existed in ancient Egypt. The Egyptians used much asphalt in the construction of cisterns, silos, and all kinds of work that they wished to render impermeable to water, and they also used it in the foundations of the pyramids.

The Phenicians, and the Arabs after them, pitched their vessels with bitumen. This is also done by the aborigines of the island of Trinidad, where there are

extensive deposits of the material. The Romans, likewise, used asphalt in their public and private structures.

In Europe asphalt was scarcely known before the beginning of the eighteenth century. The first mine was discovered in Neuchatel County, Switzerland, in 1710. Since this discovery, which was made by Dr. Eyrinys, up to the concession, in the year V., of the Seyssel mines, the asphalt industry remained stationary, and it was not till toward the beginning of the nineteenth century that it began to assume some importance.

The largest of the asphalt mines now known, that of Seyssel, extends along the banks of the Rhone between Seyssel and Bellegarde, and over an area of 20 square miles. The great deposit now in the course of exploitation is situated just in the center of the concession, at a place called Pyrimont. The work is mostly subterranean. The deposit consists of eight superposed strata separated by beds of white limestone. One of these strata is 23 feet in thickness. The working galleries have at present an extent of seven miles. The process of mining is about the same as that employed for getting out building stone.

Applications of Asphalt.—Seyssel asphalt owes its renown not only to the unique nature of the mineral employed, but also to the particular care and the improved apparatus used in its manufacture. At present, its applications are very numerous. In a pure state, it is used for paving powder mills, for draining the walls of structures built upon wet ground, for isolating vehicles from electric fluid, for preserving the floors of works where acidulated waters flow, etc. Mixed with sand, it serves for the construction of sidewalks. It has been found useful, too, for covering floors exposed to fire. The safe of the Seyssel Asphalt Company is of asphalt cement mixed with pebbles.

Preparation.—The asphalt mineral extracted from the mine undergoes different operations according to the application to be made of it. Bitumen and asphalt powder mixed give asphalt cement, of which most sidewalks are constructed. The asphalt powder is obtained by pulverizing and sifting the mineral. It is afterward submitted to the action of heat.

In the manufacture of compressed asphalt for the paving of streets, the rock is crushed, sifted, and heated. The two first operations are performed the same as for asphalt cement, but the heating is effected in a special rotary apparatus consisting of two cylinders—one rotary and the other stationary. When the powder is judged hot enough, it is emptied into wheelbarrows and carried to the place where it is to be used.

Asphalt is a bad conductor of heat. This negative property has singularly simplified the difficulties of its preparation, in that it permits of heating the powder in depots and carrying it hot to where it is to be used, without its losing any appreciable degree of temperature. In fact, the powder placed in wheelbarrows with metallic sides and an impermeable cover can be carried to a distance of a mile or more without the loss of more than 2 or 3 degrees of heat.

The process of spreading, ramming, and rolling the powder in forming street pavements is so well known that we need not dwell upon it.

The asphalt cement is also used for making flagstones, which, carried to the place where they are to be used, can be laid and cemented together by any mason, so as to reproduce the continuous and impermeable layer of asphalt that constitutes the sidewalk.

Another interesting application is beton of asphalt, which is employed with great success in foundation masonry.

A very important application of this beton has been made by Mr. Malo in submarine foundations.

Finally, we may merely mention the numerous applications made of asphalt in terraces, roofings, floorings, stables, silos, gasometer tanks, powder mills, bridges, etc.—*Abstract from Le Genie Civil.*

EARLY PRINTING IN AMERICA.

By A. DE F.

THE first press in North America, according to the best record we can find, was established at the city of Mexico, in or about the year 1600. The first press worked in the American colonies was "set up" at Cambridge, Massachusetts, in 1629. This press was secured through contributions from personal friends of the Rev. Jesse Glover in Amsterdam and England, who had the interests of religion and learning at heart. But Glover died on his passage to the new world, and so, perhaps, an honorable and historical record that might otherwise have enshrined his name among the pioneers of our early printers was lost. Stephen Day has the honor of being the first printer, and in recognition of this position he received a grant of three hundred acres of land from the government.

Pennsylvania was the second colony to encourage the art of printing. Wm. Bradford went to Pennsylvania with William Penn, in 1686, and established a printing press in the city of Philadelphia. From here, in 1692, Mr. Bradford was induced to locate and establish a printing press in New York. He received £40 per annum and the privilege of printing on his own account. Previous to this time there had been no printing done in the Province of New York, and from this date the history of printing begins its record in our city. What a marvelous stride the art has made in this period of time! The first issue from Bradford's press was a proclamation bearing the date of 1692.

It was nearly a century after a printing press had been set up in New England, before one would be tolerated in Virginia. The Southern colonists had no printing done among them until the year 1727.

There was a printing press

At Cambridge, Massachusetts	1629
At Philadelphia, Pennsylvania	1686
At New York, New York	1692
At New London, Connecticut	1709
At Annapolis, Maryland	1726
At Williamsburg, Virginia	1729
At Charleston, South Carolina	1730
At Newport, Rhode Island	1732
At Woodbridge, New Jersey	1752
At Newbern, North Carolina	1755
At Portsmouth, New Hampshire	1756
At Savannah, Georgia	1762

The first printing press established in the Northwest Territory was worked by William Maxwell, at Cincinnati, Ohio, in 1793, while the first printing executed west of the Mississippi River was done at St. Louis, in 1808, by Jacob Hinkle. There had been a printing press in Kentucky, in the year 1786; and there was one in Tennessee, in 1793; in Michigan, in 1809; in Mississippi, in 1810. Louisiana had a press immediately after her possession by the United States.

Printing was done in Canada before the separation of the American colonies from the mother country. Halifax had a press in 1751, and Quebec boasted of a printing office in 1764.

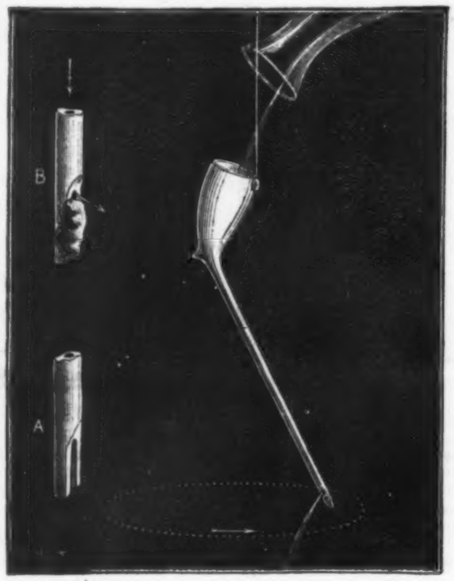
To Boston belongs the honor of the first American newspaper, in 1604, and yet in one hundred years and more from that date there were but five newspapers in the United States, while in the next hundred years, *i. e.*, 1825, there were about 600.—*American Art Printer.*

A SIMPLE BARKER'S MILL.

THE experiment in hydraulics performed in the course of lectures on physics by means of a tube provided at the bottom with two small horizontal tubes bent at the extremity in opposite directions is well known. When water is poured into the central tube, it escapes through the bent tubes, and the entire affair begins to revolve upon its axis.

A device of this kind may be made for a cent or two in the following way. Take a clay pipe and bevel off the end of the stem with a penknife, as shown at A in the figure. Close the aperture with sealing wax and drill a small lateral hole (B) in the latter. This done, suspend the pipe by means of a thread in such a way as to give it the position shown in the engraving. Leave it to itself, in order that the thread may untwist, and that the whole may become immovable. When the pipe is at rest, pour water into the bowl. The liquid will flow out through the lateral aperture, and the apparatus will revolve in a direction opposite that of the flow.

It is necessary to take care to pour the water gently



BARKER'S MILL FORMED OF A PIPE.

and in a fine stream. Finally let us add that the best material for attaching the thread to the pipe is sealing wax.—*La Nature.*

THE USE OF GAS FOR COOKING PURPOSES.

GAS as a fuel for domestic purposes has for a long time been used by housekeepers to a certain extent. It is only within a few years, however, that it has succeeded in demonstrating its superior advantages over other fuel for the purposes named. It has been the case that a great many persons believed that while gas for cooking and heating was practicable, yet it was too expensive for most people, especially those who were constantly having to figure close in their expenses. The fact has been established that gas for these purposes is the cheapest fuel. Manufactories for making gas stoves are rapidly increasing, and thousands of stoves are sold annually all over our country. The low price of gas generally has had its influence in the general introduction of this fuel. Some of the advantages resulting from the use of gas may be quickly recited:

In the first place it is always ready. The simple turning of the gas cock and applying a match is all that is necessary. No ashes, no soot, no wicks to trim, no reservoir to fill. Ordinary care should be used in keeping the stove clean, to insure its perfect working and entire satisfaction. Its use will be found very convenient and of great assistance in the sick chamber, by using a small nursery burner, and it will perfectly and positively assist in cooking the most elaborate dinner.

Cooking by gas not only does the work more perfectly and satisfactorily, but quicker and with less shrinkage than any other known method. One of the ablest gas experts of the country, not many years since, made a careful and accurate test of the relative working of a well known kitchen range and a large gas range. The results demonstrated absolutely that the gas stove would do its work quicker and cheaper with less shrinkage of food. The shrinkage was fifteen per cent. greater in the range than in the gas stove. The cost for fuel thirty per cent. greater in the range than in the gas stove.

When cooking anything that requires a steady and even heat, one can see how finely the gas stove is adapted for this, as by turning the gas on till the required heat is obtained, it will remain at that point until changed. And, again, how many housekeepers are there who have never been through the experience of being late with meals? Many a woman can testify to the advantage derived from the use of the gas stove in such an emergency over the ordinary cooking range.

Another great advantage is that of the comfort derived, especially in the summer season, when the thermometer ranges in the nineties, and when the good lady of the house is puzzled to know how to meet the oppressive heat of the atmosphere, not to mention the heat generated in the house. The gas stove at this time is really a blessing. Instead of having to endure the extreme heat of a kitchen range combined with the atmospheric heat, the housekeeper is enabled to perform her household duties with comfort.

The uses of gas for heating, as well as cooking, have also largely become a necessity, and various kinds and styles of stoves are made, from the small stove with a heating drum attachment to the large and beautifully decorated fireplace. Bath rooms, small chambers, offices, and, in fact, any room insufficiently heated by the heating system in the building is readily taken care of by the gas stove. When the seasons are changing, and when houses are chilly, but not enough so to call for the starting up of the furnace, then it is that a gas stove is appreciated and is the right thing at the right time.

The heating of water for baths is very successfully done by the use of a small gas stove, which heats a small coil of pipe through which the water for the bath tub passes. By this means a thirty gallon boiler of water can be heated from 50° to 120° in an hour, costing about three and a half cents. In fact, there are so many advantages derived by using gas for cooking and heating, that it is difficult to enumerate them.

In many gas stoves the Bunsen or atmospheric burner is used. The combination secured in this burner is two volumes of air to one volume of gas, making a mixture which burns with a bluish flame, the heat from which is much more intense than that from gas alone. A great many heating stoves are made with burners using gas alone, and when lighted throw the light on a finely polished corrugated copper reflector, making a very cheerful and attractive affair.

A few facts concerning the expense connected with using this fuel may be of interest. The quantity of gas used varies in different stoves, according to size of the burner. In ordinary cooking stoves, from six to eight feet of gas an hour for each burner is sufficient for the burners used for boiling, frying, etc.; from twelve to twenty feet per hour for roasting and broiling; from six to twelve feet per hour for heating. If it is desired to reduce the consumption to less than the above figures, all that is necessary is to turn the gas partly off. To arrive at the cost of the gas used in any burner per hour, all that is needed is the price and quantity used. Example: If a two burner stove is used just an hour and the burners using six feet of gas each, it would consume twelve feet in that time, a fair average. Taking gas at $1.60 per thousand feet, which is also fair, as most gas companies of any size do not charge more than this, which would be sixteen cents per hundred feet, or one 6-10 mills per foot. If, therefore, one foot of gas cost one 6-10 mills, twelve feet would cost twelve times as much, or one 92-100 cents, the total cost of running a stove of this size one hour. This estimate is for a two burner or double stove. For a single burner stove, it would be one half the cost, or 96-100 of a cent per hour. If larger burners are used than six feet, as is usually the case in heating stoves, the cost increases in the same proportion, but it should be borne in mind that the more gas used, the more heat is obtained. Do not these figures prove the assertion made, that gas is the cheapest fuel used for these purposes?

If there are those who doubt the correctness of the foregoing statement, they can easily test the matter and see for themselves, simply by going to the office of almost any gas company, where the desired information would doubtless be gladly given. The writer having had several years' experience in handling stoves of this kind, knows positively that all that is necessary for the general adoption of this method of cooking is that the people should acquaint themselves with the simple facts upon which it is based. Only a short time ago a gentleman said, speaking of the heating stove he recently purchased, "Why, I should think that every one would have one. It is quite inexpensive and I am delighted with it."

We allow our prejudices to influence us too often. This is one reason why so many think that it is cheaper to use kerosene for cooking purposes. I venture to say not one person in ten knows how much it costs to run a kerosene stove, simply because they buy the oil in small quantities and keep no account of it. Parties who have used both gas and kerosene for cooking, have declared that gas is the cheaper. I trust this paper may stir up some of the unthoughtful and indifferent housekeepers to an investigation of the matter, and it may result in lighter burdens and more of comfort.—*Ira B. Allen, in Good Housekeeping.*

AUTOMATIC GAS RETORTS.

THE arduous and trying labor of charging and discharging gas retorts has from the first period of gas making been a work the severity of which it has been sought, but in vain, to obviate. It is true that it had been minimized by mechanical appliances, but many difficulties have arisen in practice, so that the extended use of machines has not been so great as would otherwise have been the case. All systems proposed hitherto have had the weakness of complication, but we have now the satisfaction of directing attention to a new development of an old plan by which the difficulties hitherto encountered are overcome. This is the system of Messrs. Morris and Van Vestraut, which depends for its successful operation upon the simple law of gravitation. In this system, when once the coals are raised to a given height, varying according to the circumstances of each gas works, the whole arduous labor of charging and distributing the coal on the floor of the retort and the subsequent drawing is reduced to the most simple operation by the action of gravity alone. This is mainly effected by setting the retorts at an angle with the horizon, instead of horizontally, and governing or controlling the velo-

city of the charge of coal when being fed into the retort.

Before describing this system we may premise that the idea of an inclined retort was started by Clegg in 1804, and has formed the ineffectual basis of the inventions of several of his successors. But down to the present time they appear one and all to have missed the point; success, as is now seen, being dependent upon the proper angle of retort combined with the proper velocity of charge. M. Andre Coze, a French gas engineer, appears to have been the first to successfully apply this principle in practice, and his system will be found illustrated herewith. In our engravings Fig. 1 shows a section through a double setting of retorts on the Coze system placed back to back, and working off the ground floor with the generator under the stage and the regenerator under the sets. Fig. 2 is a transverse section of a large house for the Gas Light the flowing stream of coal comes to the stop it is arrested, and acts in its turn as a stop to the next falling portion. This action continues from below upward until the retort is fully charged. Though the speed of charging is such that four or five seconds suffice for the operation, yet the larger pieces preserve the same velocity as the finer coal, and are equally distributed. As a result of this flowing movement of the coal down the retort, it is found that the irregularities incident to the old methods of charging are removed, and that one-sixth more coal—that is seven cwt. in lieu of six cwt.—can be used in the same retort. There is no unyielding scoop to wedge against lumps, scurf, or the crown of the retort, and no uneven charging, as frequently occurs with shovel work. It is simply an even flowing layer of coal, which follows the conformation of the retort and is arrested in an instant, through the cessation of impulse of further falling coal. The retort ness. He had, therefore, to find an angle which, though it might not be absolutely the best for each kind of coal taken separately, would be most efficient in every day practice. Many trials were made, and ultimately the angle of 30 degrees was adopted as offering the best means for the varying qualities of coal to be dealt with. Successful, however, as M. Coze's system is, there are in it points of detail which do not work in well with English practice. It remained, therefore, for English gas engineers to improve upon the Coze system, and so to bring it into conformity with the necessities and conditions of gas works in this country. This has been effected by Messrs. Morris and Van Vestraut, whose simplified apparatus is shown in section at Fig. 6 of our engravings. The first point in the Coze system superseded by these gentlemen is the triple charging apparatus and the deep curved cast iron shoot to the retort. By setting the

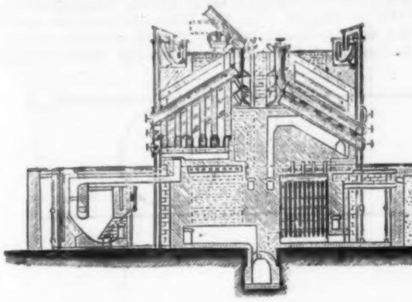


FIG. 1.

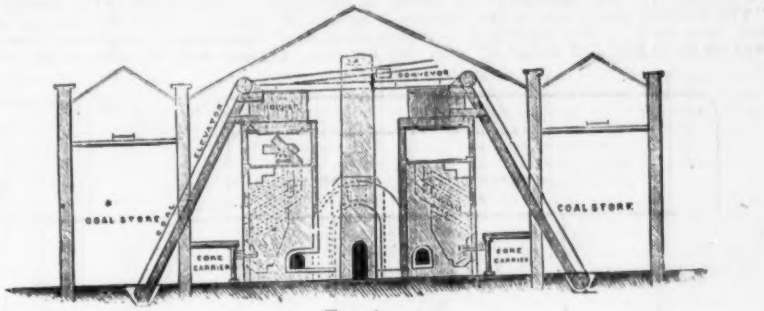


FIG. 2.

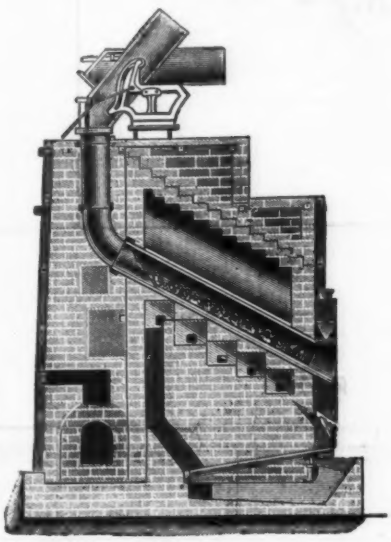


FIG. 3.

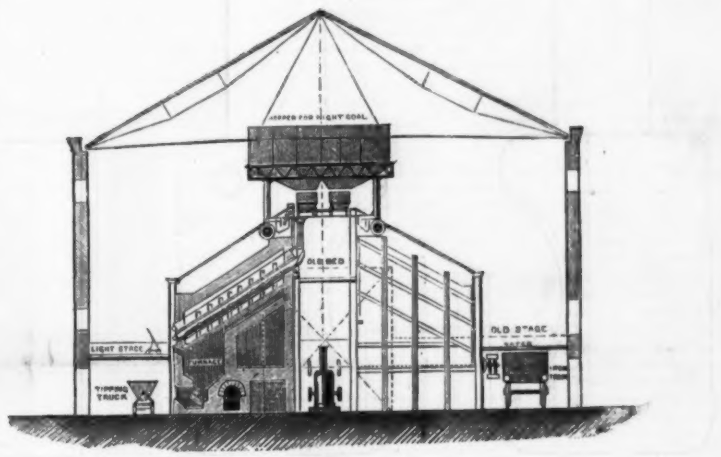


FIG. 4.

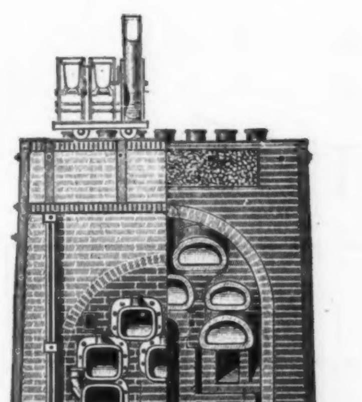


FIG. 5.

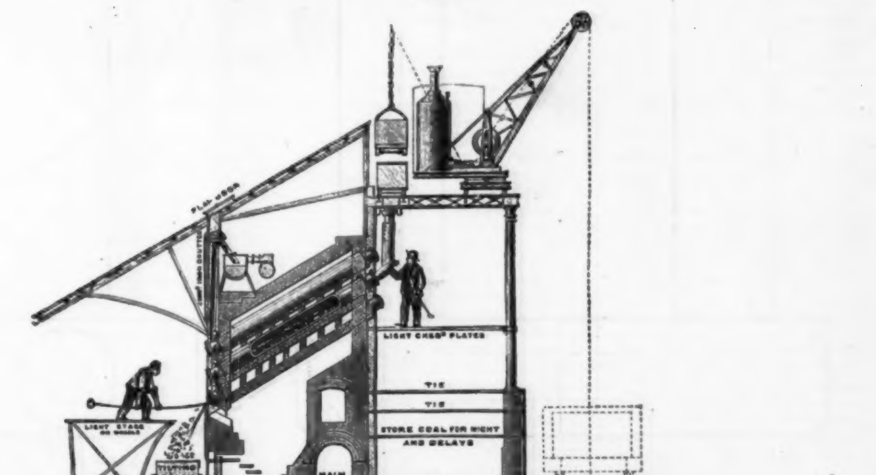


FIG. 6.

IMPROVED AUTOMATIC GAS RETORTS.

and Coke Company at Kensal Green, with Coze's single settings, showing the method of working two single settings and distributing the coal to the supply hoppers, the whole of the work being automatic. Fig. 3 is a section through the middle retort and furnace, and from which the details of the system are clearly seen. Fig. 4 is section of an ordinary retort house converted and having two sets 20 feet of modified form with ordinary retorts and fittings in place of one set, thus duplicating the capacity of the retort house, Fig. 5 being a part sectional front view of the Coze system.

It will be seen from Fig. 3 that the upper end of the retort terminates in a curved mouthpiece, through which the coals fall, so as to acquire a sufficient velocity to carry them beyond the angle of repose, and to travel downward until arrested by a movable stop, which is inserted in the mouthpiece at the lower end of the retort before closing it. As the first portion of having been charged, the top mouthpiece is then closed, and carbonizing goes on in the usual manner. At the termination of the distillation, the lower mouthpiece is opened, and the coke is seen to be held by the stop, which is removed. A light rake or slice is then introduced under the coke, which slides out rapidly as loosened by an effort which requires neither the strength nor the skill of the ordinary stoker.

This system has been in successful operation for the past four years at Rheims, where its merits have been fully demonstrated in a setting of nine retorts. To M. Coze, therefore, belongs the credit of being the first to successfully apply in practice the principle embodied in the physical law that masses of material, once set in motion, have a tendency to come to rest at an angle, varying with the form, weight, and other character of the substance. In the application of this principle M. Coze had to deal with a material which, as delivered into gas works, varies in density, size, and dryretorts on the English principle about one third of the brickwork setting is saved, and by charging the retorts from an ordinary distributing skip, the series of costly charging wagons necessary in the Coze system is dispensed with.

In the Morris and Van Vestraut system, the retorts are set at an angle with the horizon which is near the angle of repose for the class of coals in use. The upper end of the retorts, which are of the usual pattern, are fitted with the ordinary mouthpiece. At the time of charging, the lower end of a movable shoot which runs on a light rail in front of the setting is inserted in the mouthpiece. This shoot is made telescopic, so as to enable it to reach each tier of retorts, and at the lower end is hinged a shoepiece or guide. This forms an important feature of the Morris & Van Vestraut system, for by it the velocity with which the coal enters the retort is controlled. It will no doubt have been seen that the coal must not be charged at too high a velo-

city, or the whole of the charge would find its way to the lower end of the retort. Neither must it be discharged too slowly, or it would cause an undue accumulation in the mouth of the retort. The shoe can be set to the required slope, and this, combined with the angle of the retort, causes the charge of coal to be evenly distributed over the bottom of the retort. A single shoot is sufficient to serve a bench of five settings of retorts, whereas in the Coze system a separate delivery shoot is required to be built in for each retort. A full setting of sixteen 20-foot retorts on the Morris and Van Vestraut system has been put up at the Brentford Gas Works at Southall. In order, however, to test the system, a single retort was put up some time since, and has fully demonstrated the practicability of the invention. The working of this retort was recently inspected and reported upon by Mr. Perry F. Nursey, C.E., a copy of whose report is now before us. In that document he states as follows: "The working retort was of the ordinary ⌓ section, 20 feet long by 21 inches wide and 13 inches deep, and was set at an angle of about 30° with the horizon. I first saw this retort drawn. The coke in it was laid in a perfectly even bed from end to end, and it came out readily on being slightly loosened with a light slice. I then saw the retort charged with 7 cwt. of Pelaw Main coal, the usual charge being 6 cwt. for this sized retort, but, all the irregularities being filled up, a heavier charge can be used. The retort was charged in the remarkably short period of four and a half seconds."

The advantages of the new system over the old are self-evident. In the first place we have the arduous work of charging and discharging the retorts by labor superseded by an automatic process. Then there is economy in working, skilled labor not being necessary.

Beyond this comes the saving in the wear and tear of tools, no expensive scoops, shovels, or rakes being required, a slight slice being all that is wanted in drawing the coke. Scurfing, again, is reduced to a very simple process, all that is necessary being to slightly open the top and bottom mouthpieces, when the cold air rushes up, causing the carbon to contract ready for easy removal. Economy in construction is another point, inasmuch as a retort house for the new system need only be half the width of one on the old system for the same number of retorts, stage work and stage coal being dispensed with. Moreover, in converting an existing retort house to the new system, two benches of retorts can be put up in the place of the previous single bench. Another important advantage arising from the non-requirement of skilled labor is the command the new system will give gas companies over the carbonizing department of their works in the event of future labor difficulties. And this is no doubt one of the inducements to gas companies to adopt the system, for we are informed that, besides the Brentford Company and the Gas Light and Coke Company, it is being adopted by the South Metropolitan Gas Company and the principal provincial gas companies. With regard to the all-important question of the saving to be effected by the new process, we may quote the following opinion of the engineer of one of the metropolitan gas companies on that point:

"Taking cost of the setting only, and not considering any other advantages except the reduction of stage labor, the profit of this system to the gas company will be from 1s. 6d. to 3s. per retort per day, according to the plan adopted, or say an average of 2s. 3d. This, for 200 working days, gives at 2s. 3d., £22 10s. profit per retort per annum. The cost of the royalty would thus be saved in about the first two months, to say nothing of the reduction in the cost of staging, as also in skilled labor, etc."

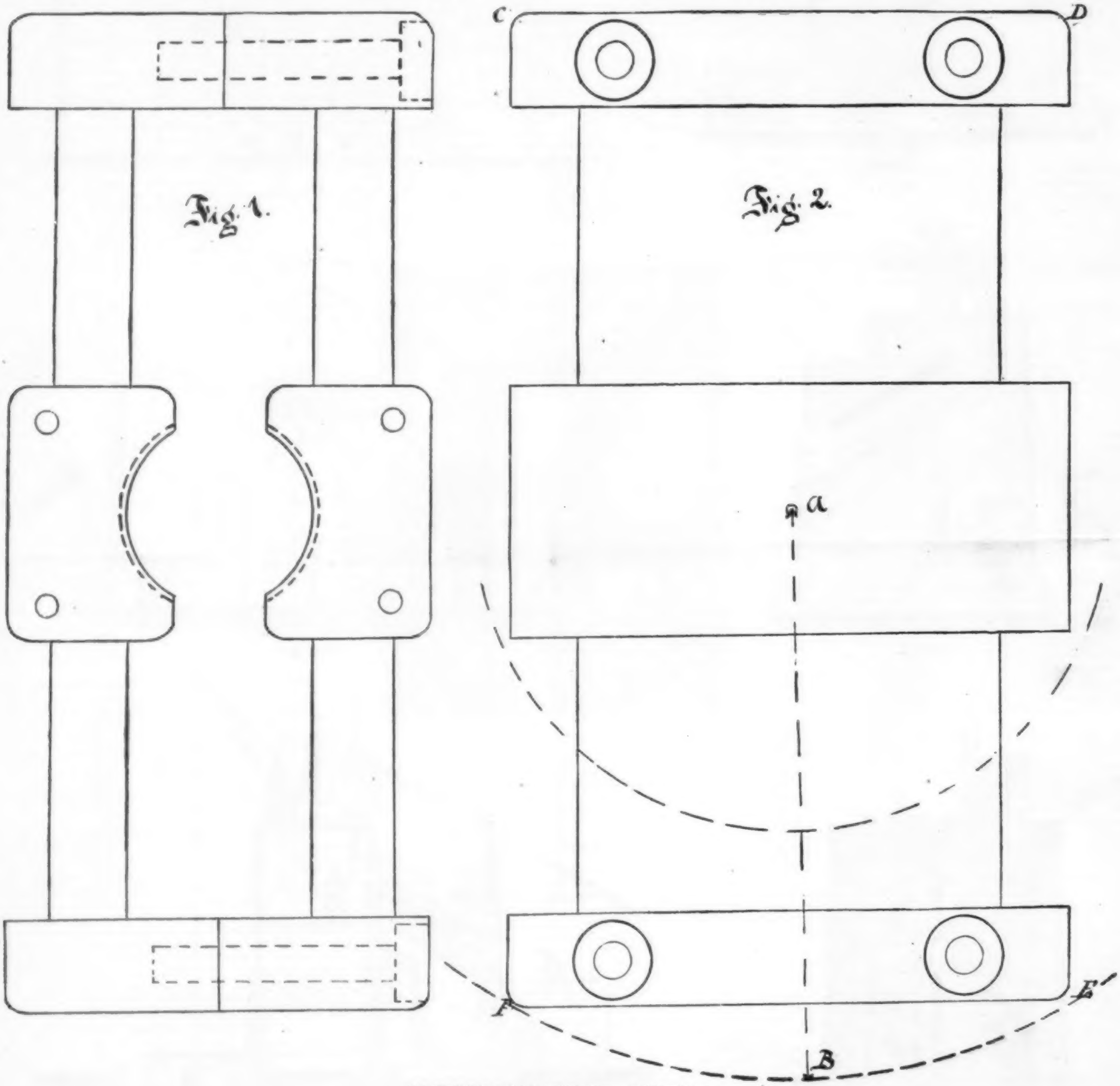
The new process is being introduced by the Coze Syndicate, London, and the chief advantages claimed for it may be summarized as follows:

1. No skilled labor required. 2. Wear and tear of carbonizing tools reduced 50 per cent. 3. Great reduction in erection of ascension pipes and hydraulic mains. 4. Coal carbonized one-sixth quicker than by the old process. 5. Absolute control of production by unskilled labor. (This is most important, especially when there is an extra demand for gas, as in the case of foggy days, etc.) 6. Fifty per cent. saving in space of permanent buildings, thus enabling a retort house fitted by this system to manufacture twice the quantity of gas. 7. This system enables the whole of the old retorts, doors, fittings, etc., to be used. 8. The Morris and Van Vestraut system effects a reduction in the cost of carbonizing from 40d. to 10d. (average London prices) per ton of coal, or a saving of over 70 per cent. in cost of labor.—*Iron.*

A SEWING MACHINE MOTOR FOR AMATEURS.

By C. D. PARKHURST.

THE limiting conditions in designing the electric motor illustrated and described in this article were the size of "swing" of the ordinary foot lathe and the desire to build as large and as powerful a motor as possible, and do all the work upon the lathe without any absolute necessity for recourse to a planer to face off the joint in the yoke or the edges adjoining the polar space. A little experimenting with lines inside of a circle, the size of such ordinary swing, soon developed a rectangle, C D E F, Fig. 2, that was well proportioned for the purpose; the line, A B, representing the "swing" of the lathe, as it gave a good length of armature and well balanced field magnet cores. In this case a drum armature was decided upon, and Figs. 1 and 2 show the relative size and proportions of the parts as finally determined upon. It will be found that the form can well be worked upon an engine lathe with 9½ inch swing, all the work of facing and boring being readily done; the ends and outside faces of the yoke are purposely in the same plane as the ends and outer faces of the pole pieces, to facilitate chucking, as in the little motor previously described, the construction being in every way similar, except upon a larger scale.

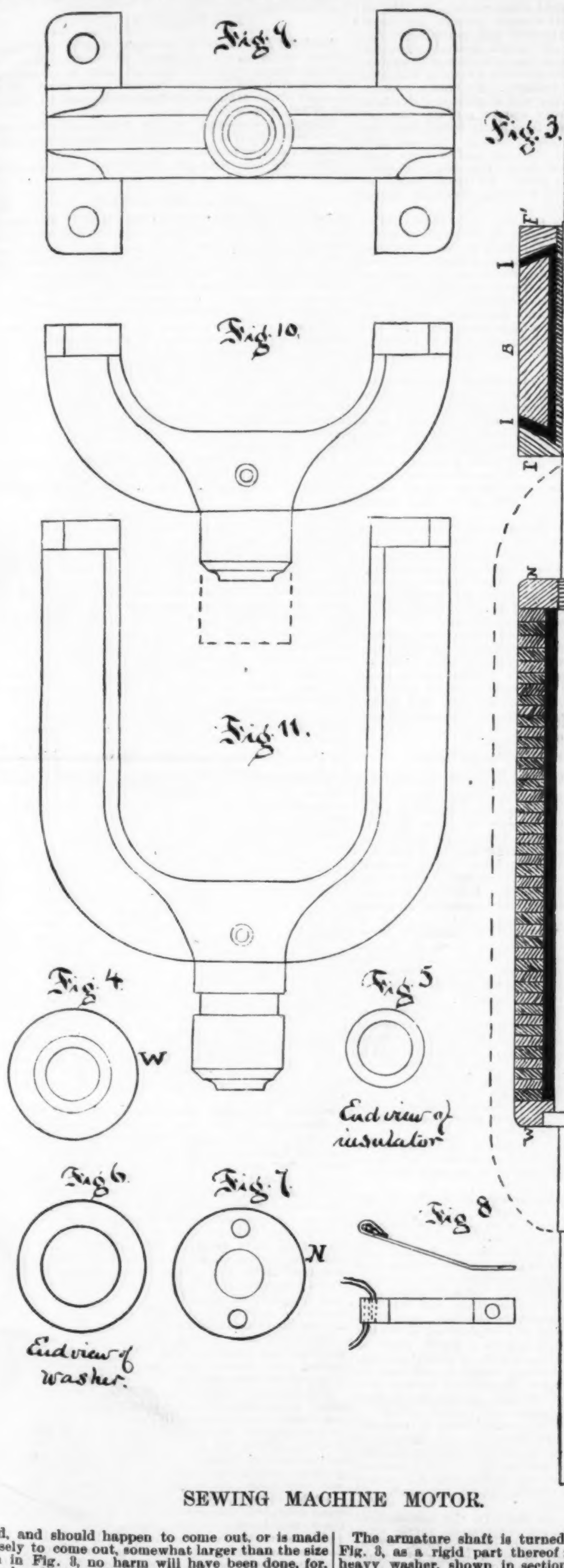


SEWING MACHINE MOTOR.

In this case, however, and in fact in all such construction, it will be found best to make the armature first, before the polar space is bored out. The yoke should be faced off first, of course, and the two halves joined together to get the approximate limit to the diameter of the armature. The armature may then be made and wound, when, of course, its actual diameter while running may be determined; the polar space may then be bored out so as to allow room enough for the armature to run freely, and yet as closely as possible without rubbing or striking. I prefer this method on account of the difficulty of allowing exactly for the thickness of insulation, space to be occupied by the wire, slight irregularities, that will sometimes happen in spite of all care, making the armature not truly cylindrical, and other causes which tend to make it a difficult matter to make an armature a close fit to a space already bored. By working as above described, it is plain that we can make the bore to fit the armature very readily, and thus insure a

close fit and as short a space as possible for the lines of force from the metal of the poles to the metal of the armature. The ends of the pole pieces should be faced off truly while the boring is being done, to insure a surface for the bearings fair and square with the bore. In this case, if the armature is made first, as above described, and should happen to come out, or is made purposely to come out, somewhat larger than the size shown in Fig. 3, no harm will have been done, for, purposely, plenty of iron has been placed in the pole pieces, and they can stand being bored out considerably larger than shown by the dotted lines *w n*, which represents more than enough room for the armature as drawn.

In the construction of the armature, nothing peculiar is to be noted except the suppression of the usual clamping rods of brass to hold the washers together. The construction adopted to avoid their use, and which has been found to work admirably in practice, is as follows:



SEWING MACHINE MOTOR.

The armature shaft is turned up with a collar, C, Fig. 3, as a rigid part thereof; against this collar a heavy washer, shown in section at W, Fig. 3, and in plan in Fig. 4, abuts, and receives the thrust of all the washers forming the body of the armature, as they are clamped up tightly by the nut, N, Fig. 3, in section, in plan in Fig. 7, as it is run up upon its screw thread, S, Fig. 3.

It will be noted that the washer, W, Fig. 3, Fig. 4, is recessed upon one face to allow the collar, C, Fig. 3, to come down flush. The outer edge is also rounded off. The nut, N, Fig. 3, Fig. 7, is also flush across its face, and has the two holes shown in the plan, Fig. 7, to allow of its being turned up to place by means of a forked wrench. This construction helps the winding by removing all projections from the end faces of the armature. The corners of washer and nut are rounded off to prevent accidental cutting of the insulation. If found to be necessary in winding, the nut and washer may be spaced off and drilled with small radial holes to receive small iron pins to help hold the wire in place while winding, the pins to be allowed to project well out, so as to be got hold of and be pulled out when the winding is completed and the binding in place.

The body of the armature may be made up of thick carriage washers as shown, or of disks of tin, in both cases paper to be used between each washer or disk. The writer has used both with good results.

If the washers are used, I prefer to bore them all out to size, so that they all have smooth, clean holes of the same diameter; they then will fit snugly and smoothly upon the insulating cylinder that is shown in the heavy black space in Fig. 3. This insulating cylinder may be of well dried wood, better yet of hard rubber, and again may be made by a wrapping of heavy paper put on with shellac, so as to be true and smooth, and baked until thoroughly dry.

Before the washers are mounted upon the shaft it is well to string them all upon a parallel arbor which just fits (an arbor with a square shoulder at one end and screw nut at the other is the kind to be used), and turn them all off to size, and at the same time take off just the edge of each washer by means of a V-point tool. This may be some trouble, but will be found to pay in the end. Now, if the washers and paper disks (heavy writing paper is thick enough, and these disks can be easily cut or punched out) are strung upon the shaft, or rather the insulator upon the shaft, and the nut run up, it will be found that there is no metallic contact anywhere from disk to disk, and the armature body will run true without further turning; whereas, if the paper disks and washers had all been placed upon the shaft and clamped into place, and then turned off, using the shaft as an arbor, the chances are that there would be metallic contact all along from disk to disk, from the edge of the iron curling over and bridging the space filled by the paper, and much trouble would result in getting rid of this contact and to insure the complete insulation of each washer or disk from its neighbor.

It is evident that with this construction washers of parallel faces are required. If of not even thickness throughout, one washer might spring the shaft, as the washers were clamped up tight by the end nut and washer. These two latter must of course be turned fair and square at right angles with their holes. But the washers may be selected that will answer, and any little burrs or projections be knocked off with the file.

It will be found that there will be no danger of turning upon the shaft if the body of the armature is properly made and tightly clamped by the end nut. Yet, to prevent possible accident, small holes may be drilled diametrically through both end nut and washer and shaft, and a small iron pin be driven through and finished off flush. The writer has made several such armatures, and they were all successful, and no accident has ever happened. The suppression of the brass clamping rods simplifies the construction very greatly in so small an armature, keeps a maximum of iron in the body, and might well be used in larger construction.

The insulating cylinder should be as thin as possible, and yet be a complete insulator. The less its diameter then the more iron in each washer, and we need as good a cross section of iron as possible to accommodate all the lines of force we can use.

The armature as shown is designed for twelve coils of No. 18 or No. 20 double cotton-covered copper magnet wire. Each coil has two layers, making four layers of wire outside of the iron. The size of the completed armature is shown in the dotted lines. If preferred for a battery of low electro-motive force and greater quantity, the winding can be with only one layer in each coil. This would increase the diameter of the body for the same sized armature, as there would be but two layers outside of the iron.

But the armature as designed, and as made by the writer for this motor, has a winding of No. 20 D. C. cotton magnet wire, twelve coils, there being two layers in each coil, and seven turns in each layer. This gives a neat and compact winding, with but small heads, and has proved to be thoroughly efficient.

The detail of winding need not be given, as it was the same as that many times mentioned in articles by others in the SCIENTIFIC AMERICAN * and other publications.

The armature having been wound and the polar space bored out to accommodate it, as above mentioned, the bearings and their adjustment next claim attention.

The form of bearing used is shown in Fig. 9, end view, and Figs. 10 and 11, plans of both front and back bearing. In Fig. 10 dotted lines will be noted, as an extension of the journal box. This is the form for the *pattern*, it having been found, from experience, a good idea to have such a projection cast in the casting, to allow something with which to get a secure and *long* grip in the chuck when boring and finishing the bearings. If not needed in the finished bearing, this projection may be cut off in the finishing, as indicated.

The writer prefers to hold the bearing in a universal chuck, and while so held, by this projection, to bore out the hole for the journal, face off the bearing faces, and turn out the inside faces before taking out of the chuck. Then—if a truly central and straight hole has been bored—the bearing faces will be truly at right angles with the axis of the hole and everything will fit fair and square without "doctoring" when we come to put the bearings in place. The finish on the *outside* of the bearings can be done by mounting upon an arbor driven in the hole. As this is of no importance, except for looks, it is not of so much importance as to truth, and the chances are against its exact truth, as the hole is a cylinder, and the arbor a cone, and it rarely drives

* For method of winding consult SUPPLEMENT 600.—ED.

exactly true, though generally true enough for such work as finishing.

The bearings having been bored and finished, the screw holes indicated in Fig. 9 may now be drilled. They should be for No. 8 or No. 10 iron machine screws, at a *close* fit.

The journals of the armature shaft, previously left purposely too large, are now turned down and polished to a *snug* fit. The armature is to be wrapped with paper enough to fit *snugly* in the polar space—care being taken to have the paper *smooth* and *tight* on the armature. The armature is now slipped into the polar space, the bearings slipped upon the journals, and the places for the screw holes in the ends of the pole pieces indicated in Fig. 1 are carefully marked. Attention should also be given to see that the bearings come up fair and square on the ends of the pole pieces. If they do not, then something is amiss, and should be rectified at once, by filing, scraping, and fitting, until everything fits fair and square, for otherwise the armature shaft will surely bind when the bearings are screwed up, causing no end of bother in final fitting to run smooth and easy and truly central in the polar space.

The bearings having been fitted, and the armature running smoothly and easily, and yet *not loosely* or with any shake, except *just a trifle end play*, the commutator next needs attention.

This is as shown in the description of the "eight-light dynamo" published by the SCIENTIFIC AMERICAN,* except that the flange, F, and the end nut, F', Fig. 3, are *undercut* as shown, instead of being square-faced, the rubber washers, I, being turned to fit. This will be found to greatly strengthen the grip upon the bars of the commutator, as it will be seen that they (and the washer of rubber) are dovetailed under heavy brass, instead of rubber alone.

The commutator *may* be made without the inside sleeve of brass that is solid with the flange, the insulator being slipped upon the shaft, the back washer coming up against a shoulder, and the front nut screwing up on a thread cut on the shaft. But this construction is not advised; for if for any reason it is desired to remove the commutator, it can only be done by unscrewing the front nut, and thus allowing the commutator to fall to pieces, or at least to become loosened and distorted.

The commutator being finished and in place, the connections with the wire of the armature are next in order. (It is of course presumed that, after winding, and while using to fit to polar space, the bearings, etc., the loose ends of wire have been properly protected from any injury or from becoming broken or loosened.)

Instead of the usual method of connecting the wires *direct* to the commutator, the writer prefers to get out some slips of heavy sheet copper, such as shown in side view and plan in Fig. 8, with which to make the connections. Each slip is drilled to receive the screw to fasten one end to the commutator bars; the other end, being first *well tinned*, is bent to form a flat loop. Each strip is thus fastened in place; the ends of the wires in their proper order and arrangement are then stripped of their insulation, and bent under the loop from *opposite* sides. A *little* solder, resin, and a *hot* soldering iron soon fasten each set of wires to its proper copper strip, and a much stronger, neater, and better fastening is the result, the principal advantage, besides strength, being in the reduction of useless resistance that must obtain with the long ends generally necessary in the ordinary way of connecting.

Before winding the field magnets it is well to stop and consider first how they are to be secured to any base that may be used, and where the necessary screw holes are to come. Also whether the binding posts for the terminals are to be mounted upon an insulating block, and these be mounted upon the outer side of one of the polar projections or not; all such work should be laid out in advance, the necessary holes drilled and tapped, and all the parts for base, terminals, etc., fitted *before* any winding is done, not only on account of there being no wire to possibly injure, but also because we have less weight to handle.

The field magnets may be mounted to stand erect as in Fig. 1, or they can be mounted to lie on one side. It is well perhaps to provide *for both*, and then the holes will be all ready for any change that may become necessary at some future day. For my part, as to the terminals, I like to see the motor as self-contained as possible, and no long connections to a base that would have to be rearranged in case of a change of base. I therefore prefer to mount the terminals upon an insulating block of rubber, fastened to the side of one of the pole pieces, and thus I can mount it as I please, or do away with a base altogether and have no connections to alter.

This having been arranged, and all parts necessary fitted to place, we now wind the field magnets with five layers of No. 16 double cotton-covered wire, the magnet waists having first been covered with cloth laid on with shellac, and the yoke faces and polar faces protected with leather, heavy cardboard, vulcanized fiber, or some other good insulator. This winding is for series connection.

The magnet waists are oval in cross section. The winding should be even and *tight*, and such as to make consequent poles of the pole pieces when all connections are made. The method need not be here described, since it is so well known to all.†

The method of fastening the ends described in a former article should be followed to get good, *secure*, and *neat* fastenings. The wire may now be varnished with several coats of good orange shellac, without any color or pigment if the wire has been kept clean, and be set one side to dry.

The brush holder is of the usual form, and, in this case, is mounted on the outside, as shown by the "hub" in Fig. 11, where the groove for the set screw is shown. This construction was purposely adopted to shorten and lighten the arms for the bearing as much as possible. It makes no material difference in the efficiency of the motor whether the brush holder be inside or outside the bearing. I prefer to have it outside any way, in the general case, for then it can be removed at any time to be cleaned or repaired when necessary without having to take off a bearing.

The bearings may have oil holes as indicated, if the motor is to stand on one end. Oil cups may be made if desired. If to lie upon its side, then the oil holes should be 90° from the position indicated. They can be drilled in diagonally at the junction of the round hub and the web of the bearing.

The brushes should be *wide*, and of several thicknesses of hard-rolled thin copper. They should bear lightly and *evenly* and at diametrically opposite points or bars upon the commutator.

The iron work of the field magnets may be finished as much as one pleases. If a good pattern has been made and a good casting turned out, perhaps no finishing will be necessary. So much depends upon the pattern and the casting that but few instructions can be given. The pattern for so small a casting will need but very little, if any, draught. Probably enough "rapping" will be given any way to permit of draught with a pattern made truly square. If the castings come out true and even, and are truly fitted, then the rough surface can be rubbed down a little and give finish enough. Otherwise the top and bottom may need turning off to be true and even, and the same with the end faces of the yoke. All these must be done, of course, before any winding, after the halves have been fitted and joined.

As a final finish a black varnish made from shellac and lamp black, laid on in successive coats to cover all the iron surface, except the ends of the pole pieces that have been turned off smooth and bright, will give a fine and glossy appearance. The brass work may be polished and lacquered, or dipped and scoured with sand to a dull finish and then lacquered. The binding posts should be polished and lacquered, and then, when all together, and the connections made, we will have a handsome and "ship shape" motor, ready to be looked at and criticised by any one, mechanic or not.

As to the efficiency of this motor and its power, the writer can only say that from the very start, now nearly two years ago, it has worked satisfactorily, running without load, or loaded, until it comes to a standstill. Started suddenly, or started slowly, there is absolutely no sparking at the brushes, unless there be dust or oil thereon, as sometimes happens after standing idle for some time. When clean, and running with its ordinary load, no sparks can be seen, even in the dark, unless one gets down and looks square under the brushes.

With six cells of plunge battery—*pint jars*—such as have been previously described, the writer has run a sewing machine through twenty-eight thicknesses of heavy drilling at a fast rate of speed. Its power has never been fully tested, for I have never had the chance; but I know I could rack my sewing machine all to pieces with it, and I have run the machine so that you could not see the needle bar.

I have described some parts of the motor perhaps too minutely; but I have so often found trouble from not knowing how things were done, that I prefer to be too minute in parts not well known rather than the reverse. Those who wish such a motor will find the money and labor necessary to make it well spent, and themselves in the possession of a handsome and durable machine.

* SUPPLEMENT 600.—ED.

† For connection of field magnets see SUPPLEMENT 641.—ED.

THE FIXATION OF NITROGEN.*

By CHARLES A. FAWSITT, F.R.S.E., F.C.S.

THE "fixation of nitrogen" is a problem which has for a long time exercised the minds and taxed the ingenuity of chemists. It is a subject of great importance from a commercial point of view, but up to the present time no satisfactory solution has been found—at least, one which will allow of it being worked economically on a manufacturing scale. The most likely compounds to be formed if its fixation is satisfactorily effected are cyanogen or ammonia or an oxide of nitrogen.

Quite recently several valuable contributions have been made to this subject, including those by Mond, Readman, and Breneman. The latter paper, which appeared in *American Jour. Soc. Chem.*, contains a very complete history of the subject, and has been of great service to me in writing this paper. I do not intend to give a complete history of the subject, as it would occupy too much time, and could not be of interest, as much of the work done has been a repetition of some published previously. In fact, all along it has been very much a case of "follow the leader;" and to show how little progress has been made, it is sufficient to mention that the trials which were made fifty years ago more nearly approached a solution of the difficulty than anything which has since been done—at least, that has been made public.

Before passing on to the "fixation of nitrogen," I will speak for a moment of the properties of nitrogen This element, as you are all aware, is of great importance.

By its presence in the atmosphere as a diluent, we are enabled to prolong our stay in this world to a far longer period than if we had an atmosphere richer in oxygen, and no gas could be substituted for it without exerting an influence prejudicial to animal and vegetable life. As regards its chemical properties, it is distinguished by its inertness, not showing, under ordinary conditions, a marked affinity for any other element; but it is owing to this inertness, and its tendency, if combined, to recover its freedom, that gives such valuable properties to our explosives, in which the nitrogen and oxygen are only in a feeble state of combination, thereby causing a state of unstable equilibrium, and a slight disturbing cause is sufficient to bring into play the stronger affinities of carbon and hydrogen, setting free the nitrogen, which helps very materially to give the explosion such sudden effect.

Nitrogen, as it exists in the atmosphere, is essential to animal and vegetable life, although it is difficult to trace its action. It exists in all albuminoid bodies, and in many organic substances is the chief component. In the mineral kingdom it exists as KNO_3 and $NaNO_3$, which form the starting point for nearly all our nitrogenous compounds.

Fixation of Nitrogen in Air.—In the atmosphere we find several nitrogenous compounds, nitric acid, carbonate, nitrite and nitrate of ammonia, which play a very important part in the economy of nature even, although the actual quantities are proportionately small to its other constituents. The ammoniacal compounds may partly be accounted for by decomposition of organic matter; but the chief agent in their production is electricity, and several processes have been based on conditions under which it was thought they must be produced in the atmosphere. Schonbein accounts for the formation of NH_4NO_2 and NH_4NO_3 by supposing that under the influence of the electrical discharge the molecule of nitrogen splits up at the same time as that of H_2O, and we get a direct combination,

$$N_2 + 2\,H_2O = NH_4NO_2$$

Again, if a mixture of nitrogen and oxygen is submitted to a series of electrical discharges, we get nitrous fumes, which, in contact with moisture, form nitric acid; and it may depend very much on the amount of the moisture in the atmosphere whether we get HNO_3 or NH_4NO_3.

Analogous somewhat to the fixation of nitrogen in air is the formation of NH_4NO_3 when a mixture of nitrogen and hydrogen is burnt.

We have also nitrogen combining with acetylene under the influence of electric discharge

$$N_2 + C_2H_2 = 2\,HCN$$

which is interesting from the fact that if the electric discharge between two poles of gas carbon was passed through a dry mixture of H_2 and N_2, it would most likely be formed from its elements. From these examples you will notice that a certain amount of work in the form of heat has to be done before the nitrogen molecule is dissociated so as to allow of it combining with the other elements.

Nitrides.—When certain elements are heated in nitrogen gas a combination is effected, and we get a nitride. For instance, we have boron, silicon, tungsten, and titanium nitrides, and these compounds when heated in steam decompose, giving off their nitrogen as ammonia. It has been advanced as a solution of the problem as to how ammonia is evolved from the lagoons in Tuscany, that boron nitride is formed and decomposed, but it is more likely to be the result of heat on organic matter.

I shall now endeavor to bring under your notice the more important work which has led up to the attempts to manufacture cyanides, etc., by fixing nitrogen.

As early as 1813 a white substance, supposed to be a chloride, was found as a deposit at some blast furnaces in Germany, but on subsequent testing was found to contain a considerable portion of cyanide. This was scarcely credited, but received ample confirmation two years later, when similar deposits were found at some furnaces which had been erected by Neilson, near Glasgow. This salt on analysis gave 48·5 per cent. KCN and 46·5 per cent. K_2CO_3. The alkaline properties of this substance had previously been discovered by the workmen, who were in the habit of taking it home to their wives as a substitute for soap powder.

Considerable interest now began to be centered in the matter by chemists, and two of the most noted, Messrs. Bunsen and Playfair, made an extensive research in order to find, if possible, a solution of the problem. Their investigations were carried out on a blast furnace at Alfreton, which seemed to have been specially designed to produce KCN, as it produced no less than 2 cwt. per day. They proved, moreover, that it was produced in the lower and hottest part of the furnace, while it was decomposed into $N_2 + CO$ in the upper part, acting evidently as a reducing agent on the fresh ore. They analyzed the gases drawn from the different heights in the furnace and found that the absorption of nitrogen was very considerable where the KCN was formed; the relation of nitrogen to oxygen being 79·2 : 22·8, whereas in ordinary air it is 79·2 : 20·8. It was thought by certain chemists that there had not been a "fixation" of atmospheric nitrogen at all, the nitrogen in the KCN coming from the coal. In order to prove the truth of this, two experiments were made, one in which a quantity of sugar charcoal impregnated with chemically pure carbonate of potash was heated in a gun barrel in a stream of pure nitrogen gas, and the other in which a similar mixture in a similar tube was heated in a stream of pure CO_2. The latter experiment produced no cyanide, the former a very considerable quantity, proving conclusively that nitrogen is fixed by alkalized carbon as cyanide.

Some one may be tempted to ask where the potash came from in the blast furnace in order to produce 2 cwt. of KCN per diem. It was found to come from the ore and coal, which contained 0·7 and 0·07 per cent. respectively.

Several eminent chemists, including Berzelius, Marchand, etc., now came forward, who said that, in order to produce cyanide from alkalized carbon, it was necessary to have moisture present, the reason assigned being that ammonia had to be produced in the first place. At this time it was well known, being mentioned by Bunsen and Playfair, that cyanides were easily produced by passing ammonia over alkalized carbon. This theory received considerable support, but subsequent experiments did not confirm it, and it seems strange how it can have received any support, as, in order to produce ammonia, we must suppose that cyanide is produced in the first place, which simultaneously produces ammonia in presence of steam; but given a certain quantity of cyanide produced, we cannot expect to receive a further quantity after it has been transformed into ammonia, and again into KCN.

Delbruch now added another important link by proving that cyanogen was formed when nitrogen was passed over heated carbon. I think, however, that this requires confirmation, as we shall see further on.

Chemists now began seriously to consider the possibility of manufacturing cyanides, ferrocyanides, and ammonia. An inexhaustible supply of nitrogen was to be got from the atmosphere for next to nothing. The working also of the process did not appear to offer insurmountable difficulties, and on the other side a large demand existed for ferrocyanides, the price for which was very much higher than at the present time.

Before bringing under your notice a few of the principal patented processes, it will be as well to mention the available sources of nitrogen.

1. We have the atmosphere.
2. The waste gases from the vitriol chambers.
3. The waste gases from the absorption towers in the ammonia soda process, the O_2 in which, I am informed by Mr. Mond, can be reduced to less than 1 per cent.
4. The ordinary products of combustion: for example, furnace gases.

* Read before the Society of Chemical Industry, Glasgow.

5. The waste gases from the manufacture of oxygen by barium oxide method, which I am told consist practically of pure nitrogen.

If air is used we must remove the oxygen, or else it would convert all the cyanide into cyanate, and, finally, into N_2 + CO. In the preparation of ammonia, the presence of cyanate is not hurtful, as it gives ammonium carbonate with steam. To effect this removal, carbon and iron are usually used, but with the latter it is difficult to free air entirely from O_2 without using a very large apparatus, increasing very much the cost of working.

It can be completely combined with carbon, but the CO, acting as a diluent, impedes the production of cyanide, etc. Adler proposes barium or calcium sulphide, but this would be troublesome and expensive. A lower oxide of nitrogen has been proposed, but never, so far as I know, successfully used.

The process proposed for the manufacture of cyanides, ferrocyanides, and ammonia may be divided into four classes:

1. By passing nitrogen or nitrogen plus aqueous vapor or nitrogen plus carbon monoxide over carbon impregnated with the salt of an alkali or alkaline earth.
2. Passing ammonia over carbon or alkalized carbon.
3. Those in which electricity is used as the agent for effecting a combination of nitrogen and hydrogen.
4. Those not classed under the other three heads.

CLASS 1.

The first patent taken out in this country was by Newton, 1843, for a foreigner, and as the Possoz and Boisiere's experiments were being conducted in France at this time, it strikes me that it was for their process. At any rate, as the two processes are identical in details, it will suffice, seeing it is more complete, if I describe the work done by the latter.

At this time Possoz and Boisiere were hard at work in France with a small apparatus, and had managed to turn out 15 tons of prussiate of potash in a year, but owing to the high price of coal and the want of good fireclay, they resolved to transfer their operations to Newcastle, where the matter was taken in hand by Messrs. Bramwell and Hughes, who imparted a great amount of skill and energy in carrying out the process, leaving no stone unturned which would conduce to its success. From the experience previously gained in France it was confidently expected the process would turn out successful, and great interest was centered in the trial.

The retorts were vertical, 10–12 ft. long, 2 ft. in diameter. The upper part was made of fireclay 9 in. thick; the lower part of iron, where the cyanized charcoal was cooled. Slits were cut in the retorts, so as to allow of the furnace gases being drawn through the mass of alkalized charcoal in the retort. It was found before this was done that the center of the mass was too cold. The retorts could be heated to a temperature at which the best Stourbridge fireclay softened. The method of procedure was to fill the retorts with wood charcoal which had been impregnated with 20–30 per cent. of K_2CO_3. Air was now drawn through the retorts until the cyanizing process was deemed complete, when the contents of the retort were lowered by means of a revolving screw into the cooling chamber. When the next batch was cyanized, that already in the cooling chamber was by the screw lowered into a tank containing a solution of ferrous sulphate, where it was converted into prussiate of potash. The charcoal after lixiviation and drying was ready for another operation. When the conditions, such as flow of nitrogen, heat, and percentage of K_2CO_3, etc., were favorable, 50 per cent. of the theoretical yield was obtained, and the yield of prussiate from a bench of eight retorts was two tons per week. The quality was very fine and obtained a ready sale. These trials were commenced in 1844 and continued uninterruptedly until 1847, during which time thousands of pounds were lost. But although it was a failure, Messrs. Bramwell and Hughes deserve great credit for having attacked the problem with a determination and perseverance rarely seen.

The chief causes of failure were—1. The loss of potash, three parts being lost for one part of prussiate made. This loss could partly be accounted for, as some combined with the material of the retort and some was left in the charcoal after lixiviation, but over and above this there was a loss which was never accounted for. 2. The large amount of charcoal which had to be lixiviated for a small return of prussiate told heavily against its success. 3. The wear and tear of the plant was very great, chiefly owing to the high temperatures employed.

From the experience gained it was thought that some of the KCN was produced from the nitrogen in the charcoal, as when alkalized charcoal was heated in air-free space they still found cyanide, but as wood charcoal contains only a very small percentage of nitrogen, it could not have amounted to much.

The yield of KCN varied with the temperature of the retorts, being greatest when hottest. The yield was also greater with wood charcoal than with coke, also with potash than soda. The yield of prussiate per unit of potash was greater than by the old process. Great stress was laid on the fact that the water must be excluded from the apparatus, as they found that when present the yield of cyanide fell proportionally. It seems strange that about this time two patents were taken out, in which the presence of water was claimed as an improvement. Ten years later an extensive trial was made at Oedenwald, in Germany. Coke balls of uniform size were saturated with K_2CO_3 and heated very strongly in vertical cylinders, but although the heat was very strong, little cyanide was produced, and the process was abandoned. It was thought that the heat had not been sufficiently strong, as on looking in the retorts the center of the mass was always very much cooler than the part next the inside surface of the retort. I pass over several patents, as there is no feature of interest. In 1862 Marguerite and Sourdeval patented what was at the time considered a valuable improvement, namely, the substitution of barium carbonate for those of the alkalies, the great point claimed being its infusibility, thereby presenting a much larger surface to the action of the nitrogen gas, and not "clogging" up the pores of charcoal. This process received a fair trial, but was given up as a failure. In 1882, L. Mond patented a certain form of apparatus in which barium carbonate is used, but as his experience is published in the last July number of our *Journal*, it will be better for those interested to refer to it. But it is very satisfactory to note that he speaks so hopefully of the future of the process.

Some years ago I conducted a series of trials at St. Rollox with a view of producing ammonia by acting on alkalized charcoal with nitrogen derived from the atmosphere, but the result was to add another to the long list of failures; but although apparently there have been so many, the experience gained in time past may help in some measure to solve the problem in the future.

My first experiments in 3 in. and 4 in. M. I. tubes gave such good results, often getting 50 per cent. of the theoretical yield of ammonium sulphate, that it was deemed advisable to erect a larger experimental plant consisting of 10 vertical retorts 6 in. diameter, 9 ft. long, 2 in. thick. The drawings will explain the construction and working of the same. The alkalized charcoal,

Fig. 1.

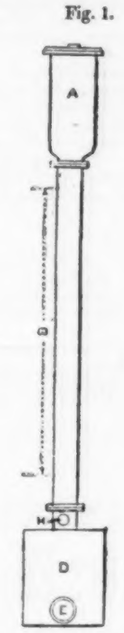
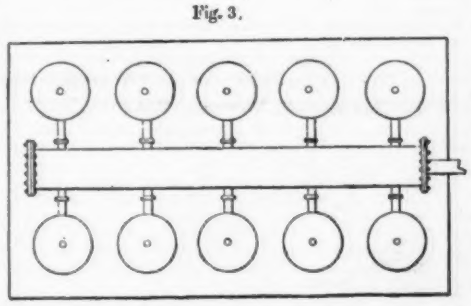


Fig. 2.

Fig. 3.



containing 25–30 per cent. carbonate of soda, was charged into the top of retort, A, which was provided with a tight fitting door; the charge having fallen into the part of the retort exposed to the fire, B, was heated there for four to six hours and then lowered by the screw, C, into the cooling box, D, another charge taking the place of the one drawn down. After remaining in the cooling box until another charge was to be lowered, it was taken out at the door, E, into luted iron boxes and hoisted up to be transferred to the retorts, where it was steamed, the ammonia passing over to a vessel containing sulphuric acid, where it was absorbed and worked up in the usual way. The nitrogen was supplied from a blower through the pipe, H, at the rate of about 1–2 cubic feet per minute for each retort, and in order to extract the oxygen it was on its way passed through to vertical retorts 9 ft. long and 9 in. diameter, filled with iron turnings and kept red hot. It was found, however, that it was difficult to deprive the air of all its oxygen, and it usually gave 3–5 per cent. O_2. The apparatus was worked continuously for some months, but did not yield $(NH_4)_2SO_4$ which anything like paid working expenses, and which had been thought possible from the smaller trials.

There was no new feature in the process other than the construction of the apparatus, and as one looks at it now, it would have been much better to have profited by previous experience. The chief cause of failure lay in the fact that a good conversion could not be obtained in the C. I. retorts, as they would not stand the temperatures required. The loss of alkali also amounted to 10–20 per cent., but if special arrangements were made this could be all accounted for. The cyanized charcoal contained about equal quantities of cyanide and cyanate, owing to the presence of O_2 in the nitrogen. In my small trials I did not find barium carbonate give so good a yield as soda or potash.

The best results were always obtained with a strong heat; in fact, when the exit pipes contained a deposit of cyanide which had volatilized, it was conclusive evidence of a good experiment. The reactions involved in the formation of ammonia in the above process are usually condensed into one,

$$2\,KCN + 4\,H_2O = K_2CO_3 + 2\,NH_3 + CO + H_2$$

whereas it would be more correctly expressed by showing it in two stages, formate of potassium being formed in the first stage,

$$KCN + 2\,H_2O = KCHO_2 + NH_3$$

Then $2\,KCHO_2 = K_2CO_3 + CO + H_2$

From cyanate only one reaction is possible—

$$2\,KCNO + 4\,H_2O = K_2CO_3 + (NH_4)_2CO_3$$

In 1887 Siepermann conducted a series of trials in order to find out which temperature was most suitable for the production of cyanides, using alkalized carbon, and his results were that a red was better than a white heat.

Weldon also, in provisional patent, 1877, says it was owing to the strong heats employed that better results had not been obtained. I think the mass of evidence is contradictory, Possoz and Boisiere's experiments being very conclusive.

The conditions existing in the blast furnace seem to furnish a good basis for the preparation of cyanides, and it has been proposed to erect one with this end in view. It has not been very satisfactorily settled as to what is the reaction which takes place when nitrogen acts upon alkalized carbon. It is usually expressed so—

$$K_2CO_3 + 4\,C + 2\,N = 2\,KCN + 3\,CO$$

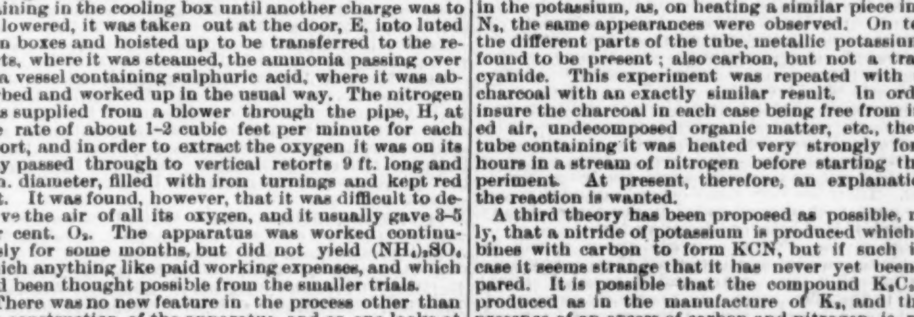
but this I am afraid tells us very little of the real truth. There are three theories advanced; one is that nitrogen in contact with highly heated carbon is converted into cyanogen, and on the reduction of the salt of the alkali or alkaline earth, it combines with the metal to form cyanides. What supports this theory is that the temperature required to form KCN is lower than for NaCN, so the temperature for the reduction of K_2O is lower than that for Na_2O.

Another theory, advanced first, I think, by Berzelius, is that potassium acetylene (C_2K_2) is first formed, and this in presence of N_2 forms KCN. But it seems strange that if such a compound as C_2K_2 exists that it has never been prepared, as it must be produced with facility, and not only the potassium compound, but also that of sodium, barium, etc.

Until recently the first theory appeared to me to be the most likely, as the formation of cyanide always proceeded quickly when the reduction temperature was reached, and taking into account the statement of Delbruch, that cyanogen is easily prepared by passing nitrogen over heated carbon, it seemed to be almost proved. There was one point, however, which seemed to be against it, and that was the fact that no method for producing metallic barium by heating the carbonate with charcoal is known, and still the formation of $Ba(CN)_2$ proceeds easily. In order to satisfy myself as to whether cyanogen was produced in the way just stated, and imitate, if possible, the reaction as near as possible, I asked my co-worker, Mr. Anderson, to carry out an experiment on the following lines: Having procured a stock of pure nitrogen by shaking up air with pyrogallate of soda, it was passed out of A through (see Fig. 4) a drying tower, B, then over wood charcoal heated to a white heat in the iron tube, C, 3 ft. long, 1½ in. diameter. The gas, which should contain CN, was now passed through a bulb tube, E, containing a piece of metallic potassium in bulb, F, and when it was deemed that the whole apparatus was full of nitrogen, the potassium was heated strongly. A moderate current of gas (about 30 liters in all) was kept up for two hours. The gas on leaving bulb, F, passed through a flask, G, containing water. At first, when the potassium melted, it remained perfectly clean on the surface, but when the temperature rose to the boiling point it gave off a white vapor consisting principally of potassium, but it gradually, where the heat was strongest, assumed a green color, and finally almost black. I think it was owing to a little impurity in the potassium, as, on heating a similar piece in pure N_2, the same appearances were observed. On testing the different parts of the tube, metallic potassium was found to be present; also carbon, but not a trace of cyanide. This experiment was repeated with sugar charcoal with an exactly similar result. In order to insure the charcoal in each case being free from inclosed air, undecomposed organic matter, etc., the iron tube containing it was heated very strongly for two hours in a stream of nitrogen before starting the experiment. At present, therefore, an explanation of the reaction is wanted.

A third theory has been proposed as possible, namely, that a nitride of potassium is produced which combines with carbon to form KCN, but if such is the case it seems strange that it has never yet been prepared. It is possible that the compound $K_2C_2O_2$ is produced as in the manufacture of K_2, and this in presence of an excess of carbon and nitrogen is reduced, N_2 at the same time taking place of O_2. This would amount to very much the same as the theory on which C_2K_2 is said to be formed.

Fig. 4.



CLASS 2.

Under this we find that Scheele in the last century obtained KCN by heating sal ammoniac, K_2CO_3, and charcoal, and was followed by Clouet and Kuhlmann, who found that cyanogen was produced by passing ammonia over heated charcoal,

$$4\,NH_3 + 3\,C = 2\,NH_4CN + CH_4$$

It was well known that NH_3 passed over alkali charcoal produced cyanide, Graeger having obtai[ned] 93–95 per cent. of the theoretical yield of cyanide [by] passing ammonia carbonate over alkalized charc[oal] contained in iron tubes 1½ in. diameter. In 1857 Ka[rm]rodt tested the latter idea and proposed to utilize th[e] waste gases produced in the manufacture of prussiate by the old method. Brinquell about this time brought out a process in which animal matter and alkali were dispensed with, advantage being taken of Clouet's and Kuhlmann's idea, in which NH_3 was merely passed over heated charcoal. If NH_4CN could be easily produced in this way, its transformation into KCN or prussiate could easily be effected.

Fleck says that he obtains 95 per cent. of the theoretical yield of cyanide from ammonia by treating a hot mixture of charcoal, sulphur, and potash with $(NH_4)_2SO_4$, the waste ammonia being again utilized, the sulphocyanate of potash reduced to cyanide by heating with iron filings. This process on testing afterward was found unsuccessful in practice.

Romily found that on allowing illuminating gas to bubble through ammonia and afterward igniting and allowing the flame to impinge on the surface of a drum revolving in a solution of KHO, KCN was produced. Still later we have the experiments of Readman, detailed already in the last October number of this society's journal.

Early in 1843 a patent was taken out by Laming for the production of cyanides by passing ammonia over red hot charcoal. In 1860 Lucas patented a process for impregnating charcoal with K_2CO_3, introducing the mixture into two vertical retorts which were strongly heated, ammonia was now passed in, when the potash was converted into cyanide. If prussiate was wanted, iron filings were added to the mixture of K_2CO_3 and charcoal. This process was, I believe, worked on a considerable scale, but proved a failure.

Webster impregnates wood with K_2CO_3, then chars the same in retorts and passes in NH_3 for the preparation of cyanides.

CLASS 3.

Under this head numerous processes have been patented, following very much on the same lines, but so far as I know none has been worked on a manufacturing scale. I select two or three from the number. Chisholm passes the products of combustion through heated retorts containing carbon, steam being at the same time injected. He says that the nascent hydrogen combines with the nitrogen to form ammonia, but if the combination is not complete the gases as they leave the retort are submitted to an electric discharge, which is said to be of great service.

Muller prepares hydrogen by leading steam over heated carbon, and stores it in a gasometer. Nitrogen is likewise prepared by passing air over carbon, absorbing the CO_2 produced, and storing the nitrogen. The gases, in proportion 3 vol. H, 1 vol. N, are now passed through a tube, being at the same time subjected to an electric discharge, when, he says, ammonia is formed.

Young submits H_2 and N_2 to action of electric discharge in presence of aqueous vapor; he claims this as a decided advantage.

CLASS 4.

Under this head we have a large number of different ideas brought out. Solvay proposes to impregnate fuel with calcium chloride and mix it with limestone or other base. The mixture is then charged into a cupola, steam or air being admitted through the incandescent fuel. Chlorate of ammonium is now formed and condensed. It is claimed that by the use of a decomposable chloride the limits of temperature for the successful carrying out of the reaction are not so narrow as when alkalized carbon is used in the ordinary way.

Bassett produces boron nitride by heating a borate with charcoal and alkaline carbonate, the reduction of the latter salt to metal bringing about the formation of amorphous boron, which in an atmosphere of nitrogen forms boron nitride. This compound is then decomposed by heating in presence of aqueous vapor and the ammonia absorbed in the usual way.

Dufrene passes air or nitrogen over charcoal which has been soaked in platinic chloride and heated to produce finely divided platinum. Hydrogen is passed over the prepared charcoal under pressure, when ammonia is said to be formed.

Twinch states that he gets nitrogen into nascent state by depriving air of its oxygen with nitric oxide. This nitrogen is then brought into contact with nascent hydrogen made by passing steam over a metal or by action of zinc on an alkaline hydrate, when NH_3 is formed. There are very many others, but as they are for the most part comprehended under those already mentioned, it is of little use detailing them.

Future of the Process.—In conclusion it will be advisable to consider whether or not there is any hope of the process in the future, and, if asked, I should answer in the affirmative. As previously mentioned, Mond takes a hopeful view of the process in which barium oxide is used as the base. Taking present prices as a basis, I should say there is a very much better chance for success if cyanide or ferrocyanide are the products aimed at, as shown by following figures:

1 ton of N_2	will produce	4·7 tons	$(NH)_2SO_4$	at	12 *l.*	per ton	= 56 *l.*
1 " N_2	" "	5·0 "	$K_4Fe(CN)_6$	"	63 *l.*	"	= 315 *l.*
1 " N_2	" "	4·6 "	KCN	"	162 *l.*	"	= 745 *l.*

You will see that the N_2 converted into KCN has 15 times, and if into ferrocyanide nearly six times the value that it has if turned into sulphate of ammonia, and as new sources of application for KCN have lately arisen, and thereby increased the demand in a very marked degree, it seems as if attention should be more specially directed to this article. It seems strange converting K_2O or BaO into cyanide for the production of NH_3 when cyanide commanding such a high price has to be decomposed into ammonia, an article of comparatively little value. As to which base is the best for the preparation of cyanides, opinion is divided generally between K_2O and BaO; of course it depends very much on whether ammonia, KCN, or prussiate is to be the ultimate product. If KCN, taking into account the various results, one would fix on K_2O as if BaO were used. BaCN would require to be reconverted into KCN, which, however, would be easily accomplished by adding K_2SO_4. If ammonia was desired, taking into account the statement by Mond, one would declare for BaO, as, owing to its relative infusibility and non-volatility, it is specially suited to regeneration. I think, however, we should not overlook the claims of ammonia as a base, as it possesses important advantages over the others. If it is a fact that NH_4CN can be easily produced by passing NH_3 over heated charcoal, as has been stated by several chemists, it seems to be of great importance, because we have here a base which has no action on the retort, and as neither it nor the NH_4CN, seeing they are both volatile, are retained by the charcoal, no lixiviation would be required. As regards the conversion of the NH_4CN into KCN, this could be accomplished by passing the former as it issued from the retort through a hot concentrated solution of KHO, whereby the NH_3 would be set free and could be returned to the retort to be again converted into cyanide. One great point in having a volatile base is that as the products of the reaction are formed they are removed out of the sphere of action, and so the reaction is allowed to go on without interruption. Pressure, if it could be applied, would no doubt help this process to a satisfactory conclusion.

It seems to be a question of apparatus more than a modification of any of the processes named which will help to solve the problem, and it seems as if fireclay retorts of not too large dimensions, heated very strongly, would be required, and the nitrogen will have to be almost free from other gases. Considerable attention is being devoted to the question at present, and any experience that I have gained is at the disposal of any one interested in the matter.

IRON PUTTY.—The iron putty used for steam joints is made by mixing dry 2 parts of a good metallic paint, 1 part litharge, 3 parts fine iron borings sifted, or for close joints, iron filings. Add boiled linseed oil and mix to the consistence of stiff putty.

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